ENGINEERING OFFICE SYSTEMS AND METHODS

TOGETHER WITH

SCHEDULES AND INSTRUCTIONS FOR THE COLLECTION OF PRELIMINARY DATA FOR ENGINEERING PROJECTS; SAMPLING, INSPECTING AND TESTING ENGINEERING MATERIALS; CONDUCTING DOMESTIC AND EXPORT SHIPPING OPERATIONS; ETC.,

BY

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PREFACE

This book had its inception in a collection of "reminders," such as are commonly used in engineering offices for checking drawings and specifications. To these "reminders" were added from time to time original matter relating to engineering office routine of a kind not usually found in books, and extracts from articles in periodicals, catalogues and engineering books relating to the general subject of engineering office systems. From this beginning the present book has been developed. It is arranged to follow as nearly as possible the progress of an engineering development.

Criticism may perhaps be made that such subjects as soil testing, stream gauging, domestic and export shipping, etc., do not properly belong to a discussion of engineering office systems. However, during several recent years of experience as an office engineer, the author has frequently been called upon to deal with just such matters as these, and believes that generally the office engineer is required to handle such problems.

Other subjects may appear to be unduly emphasized, such as structural steel work, but this branch of engineering is so common to all undertakings of magnitude that the author felt justified in devoting considerable space to the subject. At the same time the limitations of space prevented full treatment of other material which may be of less frequent use but of no less importance to office engineers.

The forms given in the text are not, of course, adapted to immediate use in all cases. They are given as suggestions only, in the hope that they may be of service in the production of forms for similar problems.

Acknowledgments are gratefully made to all who have contributed to the preparation of this volume, both at first and second hand. More especially the author is under obligation to the Honolulu Iron Works Co. (Mr. D. A. Fox, Manager, New York office), for permission to reproduce many forms and methods; to Mr. O. M. Brown of the same company for criticisms and suggestions in connection with the chapters on Domestic and Export Shipping, and to Mr. A. P. Leonard of the same office for assistance in the preparation of the material relating to Electrical Engineering, etc. Acknowledgments are given in the body of the text to many sources of information which have been drawn upon. Of necessity the work was largely one of compilation, and the author wishes to acknowledge freely his indebtedness to many men for material which has been included herein.

JOHN P. DAVIES.

NEW YORK CITY,
January, 1915.

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ENGINEERING OFFICE SYSTEMS AND METHODS

CHAPTER I

COLLECTION OF PRELIMINARY DATA FOR ENGINEERING PROJECTS

Introduction

It is proposed in this chapter to give lists of "reminders," outlines of methods, etc., incidental to the collection of preliminary data in the field, on which to base engineering designs, estimates, reports, etc. In most cases, on important work at least, an engineer will be sent from the office to obtain the requisite information; on smaller work, however, and where only approximate estimates and reports are required, the information may be gathered and submitted by local men, and to the latter, particularly, this chapter is addressed.

For the projects as a whole, "reminders" only are given; but in the case of detail operations applying to a variety of investigations, sufficient information has been given to enable the engineer to make his own tests, even though the class of work be somewhat foreign to his own particular experience.

SEC. I. QUALITATIVE FOUNDATION TESTING

Foundation Testing and Sub-surface Prospecting: General Observations

The tools and methods used for obtaining information concerning foundation conditions and for sub-surface prospecting are, in most cases, identical, and can well be considered under one heading. While in prospecting it is only required to ascertain the character of the underlying strata, in foundation testing it is also sometimes necessary to determine their bearing value under applied loads. The methods, therefore, may be classified as qualitative and quantitative.

It is trite to state that the subject is of the greatest importance, recurring failures of large structures constantly remind us of this, but a point that does not seem to be generally borne in mind is that **on smaller work, even, a slight expenditure of time and money in foundation testing will often be many times repaid.** Even if the completed structure does not fall or settle it is often possible to save tremendously in the cost of foundations by using a design based on absolute knowledge and one best adapted to the conditions. The following is one instance among many that have come to the personal attention of the writer; any engineer of a few years' experience will be able to recall similar occurrences.

A steel railroad trestle bridge was designed for an estuary-crossing in a foreign country; the only data submitted was a "profile and base-of-rail" diagram, and the bridge was wanted in a great hurry. The anchor-bolt plan was sent to the railroad company, and, at about the time the steel arrived at the site, the foundations were being put in. It was then found that the excavation for two piers near the water's edge was going to be exceedingly difficult, as a boulder formation, subject to scour and of unknown depth was encountered. However, after months of delay and at the cost of thousands of dollars these piers were finally completed. All this could have been avoided had a few days' time been taken to sink test-pits and make borings along the bridge site, and had the results, with recommendations concerning location of towers, been forwarded to the steel designers.

The **usual methods in use** for exploring the sub-surface are: (1) Open pits, (2) post-hole digging, (3) auger borings (with or without casing), (4) wash borings, (5) core drilling with diamond drills, etc.

These methods will serve to indicate when a stratum of known bearing value has been reached; but in the case of untried material or that of low bearing value, the methods of measuring the safe bearing pressure that are given in following sections will have to be used.

Considering now the utility of the above operations, it may be said that, within the limits of its operation, the **Open Pit** method of prospecting is the one sure procedure for ascertaining the character of underlying strata. In **dam building** especially, as many pits as are necessary should be sunk over the site, one of the particular objects of the exploration being to ascertain the existence of thin beds of unctuous material, lines of cleavage in the strata, faults, or any other such lines of weakness that may allow "slipping" under the action of the thrust or under the vertical load on inclined strata. It should be remembered that dam locations, being in valleys, are frequently the sites of great geological displacement, notable cases in point being the Woodhead Dam of the Manchester (Eng.) water works, and the Kensico Dam (N. Y.) of the New York City water works system.

The pits may be partly or wholly timbered; and, if desired, a test of the bearing value of the bottom may be made in the usual manner.

The use of the **Post-hole Digger** is restricted to holes about 5 ft. deep; or, if a digging bar, round-point shovel and spoon be used with handles 8 ft. long (such as are used on telegraph work) the holes may be dug up to 12 ft. deep. For investigating shallow foundation material, for determining the depth of overburden on an ore deposit, or for similar conditions, these tools will often be found convenient.

Augers often offer a cheap method of prospecting in the lighter soils, and have the advantage over wash-boring methods that a more or less accurate sample can be obtained of the strata traversed. The tools

used vary from the common carpenter's auger attached to a rod or length of pipe, to machines that will sink wells several hundred feet in depth, will traverse rock, and will bring up a "core." Their use, therefore, covers a very wide range, and in the following sections a number of different rigs are described. Many holes can be sunk without casing, but when the top material is loose, or the hole is very deep, it must generally be used.

Wash Boring or jetting, also, can be conducted with very simple, home-made apparatus for holes of moderate depth; or, by using more complete outfits, can be prosecuted to depths of 500 to 600 ft. In this method water is led into the hole through a pipe of relatively small diameter and forced downward through a drill-bit against the bottom of the hole. The stream of water loosens the material and the finer portion is carried upward and out of the hole by the ascending water current: the drill-pipe being turned slowly during drilling to insure a straight hole. Casing is usually sunk as fast as drilling proceeds. Cuts of the tools are given in following sections. The method is cheap and is very largely used for prospecting on canal routes, etc., where it is necessary, only, to ascertain the general character of the material that will be encountered, or to locate bed rock for proposed foundations. It is subject to the disadvantage, for foundation prospecting, that the water frequently hides the true character of the strata, so that thin beds of weak material are liable to be overlooked. For this reason the results of wash borings alone cannot be depended upon when planning foundations for important structures, and some other "positive" method, say, of open pits or core-drilling, must be used to supplement the results.

The advantage of **Core Drills** over all other types of boring machines[1] is that they enable an accurate sample of the material penetrated to be obtained. They are therefore widely used in prospecting for coal and other economic deposits, for making borings for foundations for dams and similar structures, in preliminary tunnel investigations, and in excavation work. The importance of obtaining a true sample of the material penetrated is illustrated by the experience of a firm of contractors, who became bankrupt because at a certain depth they encountered hard conglomerate, instead of the gravel indicated by the drillings of a percussion outfit. Rotary core drills of the several classes are alike in employing a hollow rotary drill that by abrasion wears an annular hole, leaving a core in the center. The drillings are removed continuously by water under pressure and the core is broken off and removed from time to time.

Methods of Making Test Borings with Hand Augers

For Ascertaining Character of Foundation Soil.—The following is extracted from an article by A. C. D. Blanchard, Assistant Engineer, Toronto, Ont., in the "Canadian Engineer" for July 30, 1909.

[1] U. S. Geol. Survey Water Supply Paper No. 257.

The borings were made in the city of Toronto during the last year in order to find the character of the soil to a depth of from 30 to 70 ft. These borings were made in connection with several works which were about to be built, and were taken in different parts of the city. The ground met with consisted chiefly of blue clay, although seven borings were made in wet, sandy clay, and four were made in filled ground. The borings were all made with a 1 1/2-in. carpenter's machine auger, welded to the end of a 3/4-in. pipe. The 3/4-in. pipe was cut in sections 6 ft. long, and each length was added as it became necessary.

In the process of boring the auger was turned by two or three men with Stillson wrenches, at the surface. The heavier clay required three men to turn the auger. After the auger had bored from 8 to 12 in. it had to be removed from the hole and cleaned and then replaced in the hole, and continued for another auger length. Considerable time was thus lost in having to remove the auger and getting it back to its position again, especially after the hole became quite deep. Samples were taken from each boring and bottled.

Hand Auger Prospecting.—The following description of tools and methods is extracted from Gillette's "Handbook of Cost Data," p. 142.

"Mr. Charles Catlett is authority for the following methods of prospecting for deposits of hematite in Virginia. The set of tools consists of a steel auger bit twisted into a spiral (4 turns) 2 in. diameter, the steel of the bit being 1/4 in. thick and 13 in. long and provided with a split point. This bit is welded to an 18 in. length of 1-in wrought pipe having a screw threaded end. Another chopping bit for use in hard material is made of 1 3/8-in. octagon steel with a 2-in. cutting edge, and is welded to a length of 1-in. wrought pipe. As many lengths of 1-in. wrought pipe are provided as necessary, with screw couplings. An iron handle, 2 ft. long, is provided with a central eye and with a set screw so that it can be fastened to the 1-in. pipe at any place. A 10-ft. length of 1 1/4-in. pipe, threaded at each end for connection to the 1-in. pipe is provided for use in giving weight to the pipe drill rods in churning. The other tools are: A sand pump of 1 or 2 ft. of 1-in. pipe with a leather valve, and cord for lowering it; two pairs of pipe tongs; two monkey wrenches; 25 ft. tape; flat file; spring balance; oil can; water bucket; etc. In boring through soft material, the auger is rotated by two men, raised every few minutes, scraped clean, and the handle fastened higher upon the rods. In hardpan or rock the churn bit is used, and the sludge is removed either with the auger or with the sand pump. The greatest depth penetrated with this outfit was 80 ft. Up to a depth of 25 ft. two men suffice; from 25 to 35 ft. three men; 35 to 50 ft. three men, the third man standing on a rough timber frame 15 or 20 ft. high, so that the pipe need not be unjointed when raised. For depths of 50 ft. more the pipe is unjointed when raised."

Earth Augers as Used for Well Boring.—The following description of tools and methods is taken from Water Supply Paper No. 257 of the U. S. Geological Survey: it contains several hints that will be found helpful in making borings for foundations or prospecting.

In alluvial deposits along streams and in other unconsolidated deposits of gravel, sand, and clay, wells 2 or 3 in. in diameter are in some parts of the country bored to the ground water level with a hand auger made by welding a carpenter's

auger to a rod or pipe. The auger works more efficiently if the centering point is cut off and the lips are shaped as shown in Fig. 1 (3). A wrench formed of a plumber's tee and two short pieces of pipe may be used to screw the auger into the earth and pull it out with its load of material, and the rod may be lengthened by adding other sections of pipe as sinking progresses.

Another much-used type of auger is formed by making a spiral coil of tire iron, shaping a cutting bit on its lower end, and welding or riveting the auger thus formed to a joint of rod or pipe, Fig. 1 (2). Where the depth to water is not more than 25 ft. these small augers may be fastened to a section of pipe long enough to reach to water. As the auger is heavy when loaded with material, a windlass or a small derrick with pulley blocks may be used in lifting it, and a platform may also be built from which the auger can be steadied and turned. In boring through dry sand or other loose deposits a little water should be poured into the hole to cause the material to cling to the auger.

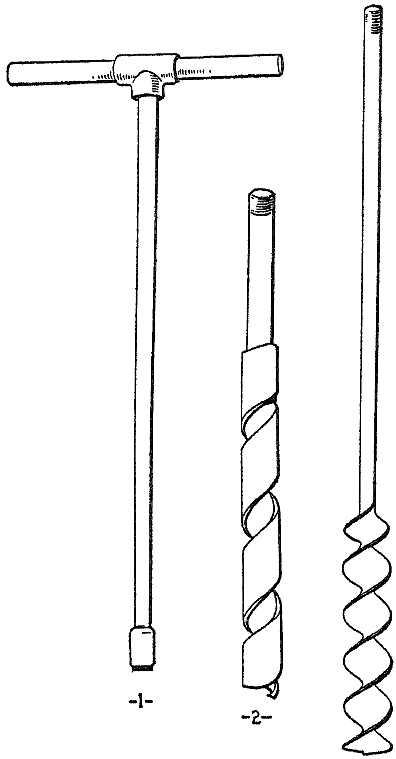


FIG. 1.—1, small earth auger; 2 and 3, earth-auger bits.

Improved Auger Methods

Auger methods of earth drilling have been brought to perfection in the "Empire" prospecting drill, manufactured by the New York Engineering Co., 2 Rector St., New York City, from whose catalogs and pamphlets the following description is extracted.

While these drills are primarily designed for drilling placer ground, where it is necessary to obtain samples which can be analyzed to ascertain their gold content, and where an accurate sample is, therefore, of the first importance; they are, also, no less useful for all other kinds of boring work within their capacity.

A general **view of the outfit** in operation is shown in Fig. 2, and details of the drilling pump and cutting shoe in Fig. 3. Many other tools and attachments are used, but space forbids their description in this article.

The **outfit consists of** a casing (lighter than drive pipe) with a toothed cutting shoe screwed to the lower end. A platform is placed on top of the casing and men standing on the platform operate one of a variety of tools inside the casing, alternately raising and dropping the tool as in churn drilling. At the same time other men rotate the casing by means of poles attached to the platform, or a horse harnessed to a sweep. The casing with its cutting shoe, by its own weight

and that of the platform and men standing on it, cuts into the ground, there being but little friction to overcome, as it is kept loose by rotation. A tool which drills and pumps material into its barrel simultaneously is generally used. Thus the casing is sunk and the material is drilled and pumped at one operation, with the

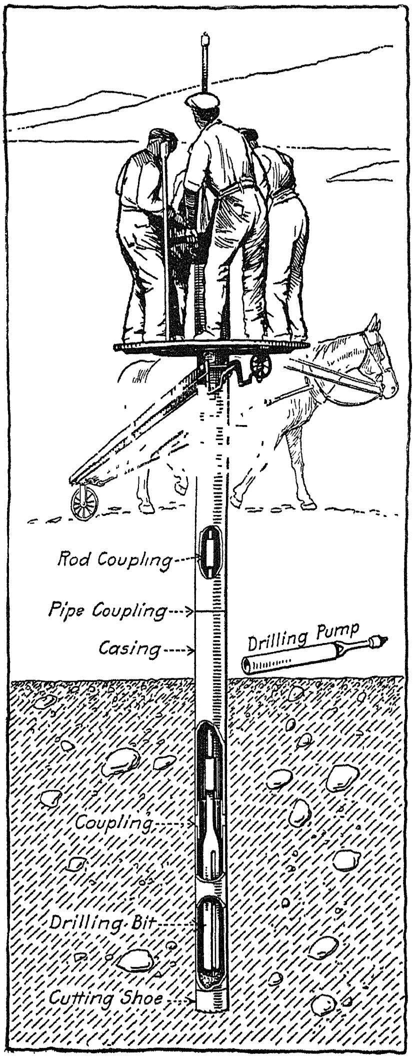


FIG. 2.—"Empire" prospecting drill in operation—sectional view.

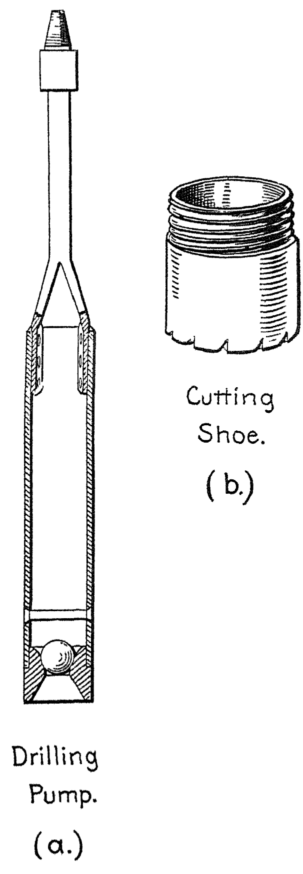


FIG. 3.—Details of "Empire" drill.

same result that is obtained in the three operations of the power drill. Several kinds of pumps are used, equipped with ball or flap valves. The pump fits the casing and as the pump is dropped it causes a rush of water into the barrel from below, the drilled material being carried into the barrel and held there by the ball valve.

Only a few strokes of the drill pump—ten to fifteen—are necessary to fill the pump. A small amount of water must be poured into the casing for the drill pump to work in, if the gravel contains no water.

The material from the core is drilled with the drill pump, and when the pump is filled it is raised to the surface by disconnecting the rods, and the contents are emptied into the dump box for examination or panning.

When **large boulders** are encountered, a Heavy Rock-drilling Bit is attached to the lower end of the rods, instead of one of the drilling pumps, and the boulders are readily drilled through, or else broken or split, by the combined action of the drill and the casing with its sharp cutting edge. The casing is sometimes driven by a driving ram and the boulders are thus driven aside or shattered or split; or a stick of powder may be exploded in the bottom of the hole, after pulling the casing up a foot or two. The boulder is thus shattered and the hole continued.

When **buried timbers** are encountered the Timber Cutting bit will readily cut through these, while the rotated cutting shoe assists in this work.

The **casing is pulled** by attaching a pulling cap to the top of the casing and using a long pole as a lever, with an adjustable fulcrum or pulling stand; or, in case of deep holes, by using a pulling jack.

The **light weight and portability** of the apparatus is one of its particular advantages. The weight of the 4-in Empire Drilling apparatus, without the casing, is about 1,000 lb., but no piece weighs over 75 lb. The casing is made in sections which weigh about 50 lb. The 6-in. drilling outfit without casing weighs about 2,000 lb., but no one piece weighs over 100 lb.

An Empire Junior hand drill outfit, using 2-in. I. D. casing, including a rotating head with platform attached, arranged with a lever attachment for rotating the casing, drill handle, drilling tools, drilling pumps, casing cutting shoe, driving ram, casing pulling apparatus, etc., weighs about 300 lb.; but no one piece weighs over 30 lb.

Capacity.—The principal field for these drills has been in ground up to 40 or 50 ft. deep; at greater depths, however, the operations can be carried on just as readily by the use of a spring Drilling Winch to counterbalance a part of the weight of the drill rods and tools. Depths of not to exceed 200 or 250 ft. in conglomerate or materials of a similar nature can thus be attained.

A Jetting Outfit for Well Drilling

The following description and cuts (Fig. 4) are extracted from Water Supply Paper No. 257 of the U. S. Geological Survey. While they apply particularly to well-drilling operations, the tools and methods are in every respect similar to what would be used in prospecting work.

In the jetting method of well sinking the material is both loosened and carried to the surface by water under pressure.

The principal parts of the outfit are a force pump and water swivel, drill pipe, nozzle or drill bit, casing and drive weight.

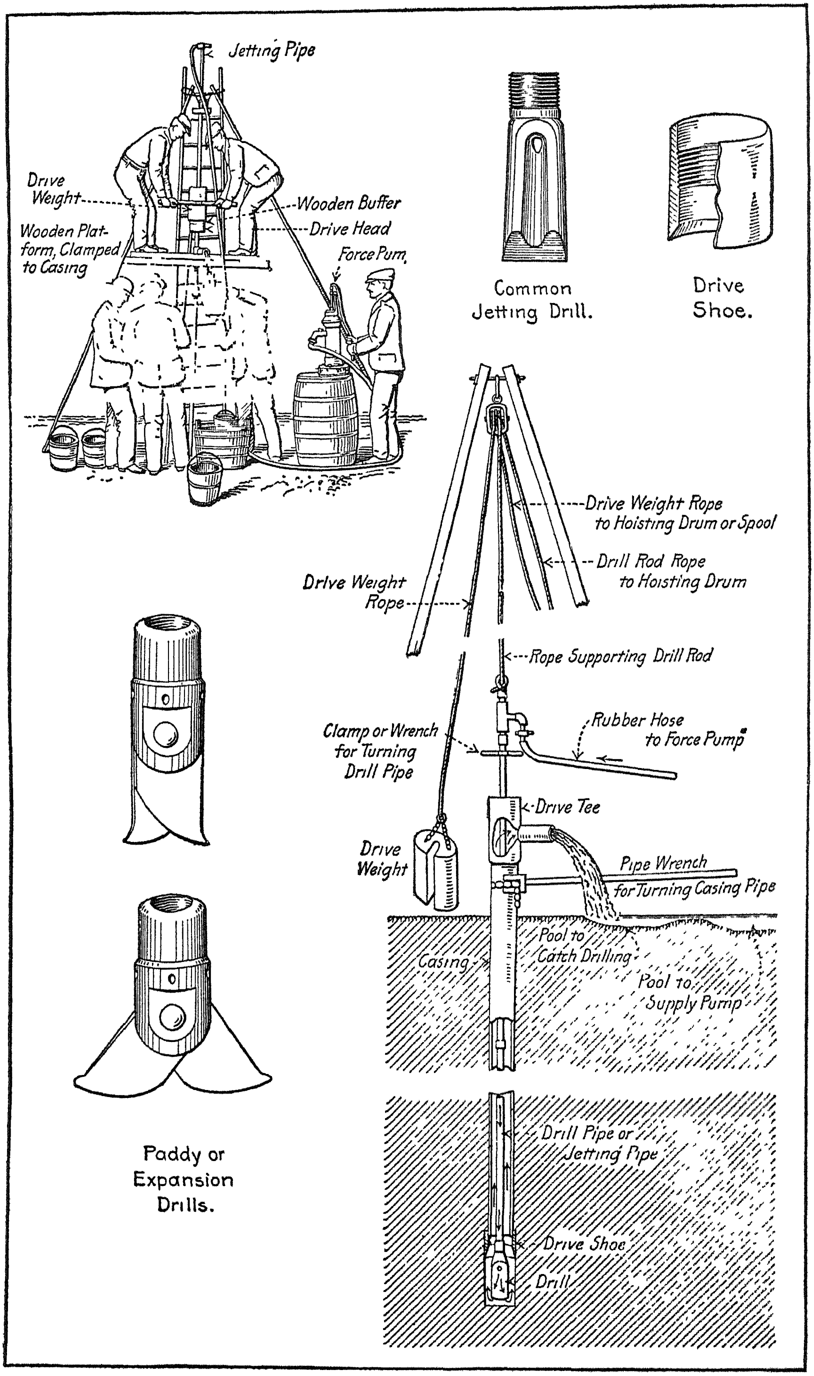


FIG. 4.—Jetting outfit for well drilling.

Hand-power jetting outfits are made in several styles which differ chiefly in the arrangement for driving the casing. One outfit uses a block and tackle for raising and letting drop a weight of 200 lb. or more; another uses a lighter weight which is lifted directly by hand. Some outfits require a light derrick and working platform; others are operated from the ground. In a light hand-power rig like

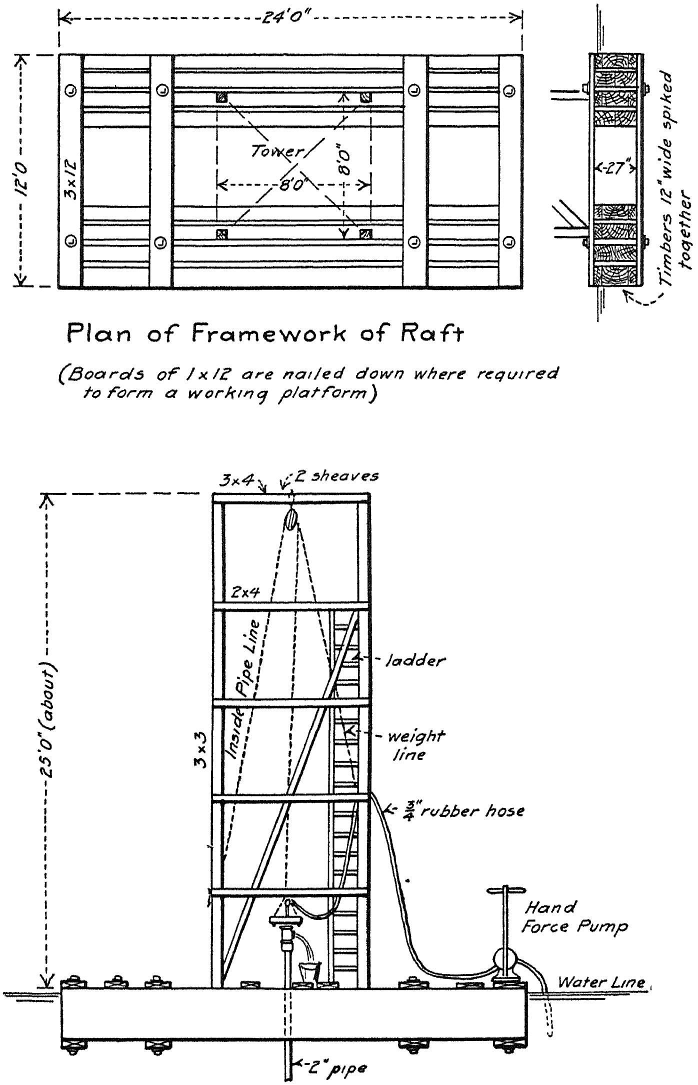


FIG. 5.—A boring rig for river and harbor work.

that shown in the figure, the casing is about 2 1/2 in. in diameter and the drill pipe about 1 in. The larger machines have a mast and hoisting sheave and use engine power for handling the casing and drive weight and for working the pump.

Casing is usually sunk as fast as drilling proceeds. In the softer materials,

by using a paddy or expansion drill, a hole may be made somewhat larger than the casing, which may be lowered a considerable distance by its own weight. Ordinarily, however, a drive weight is necessary to force it down. As a rule one size of casing may be employed for the entire depth of the well. It is usually difficult to drive a single string of casing beyond 500 to 600 ft. by this method,

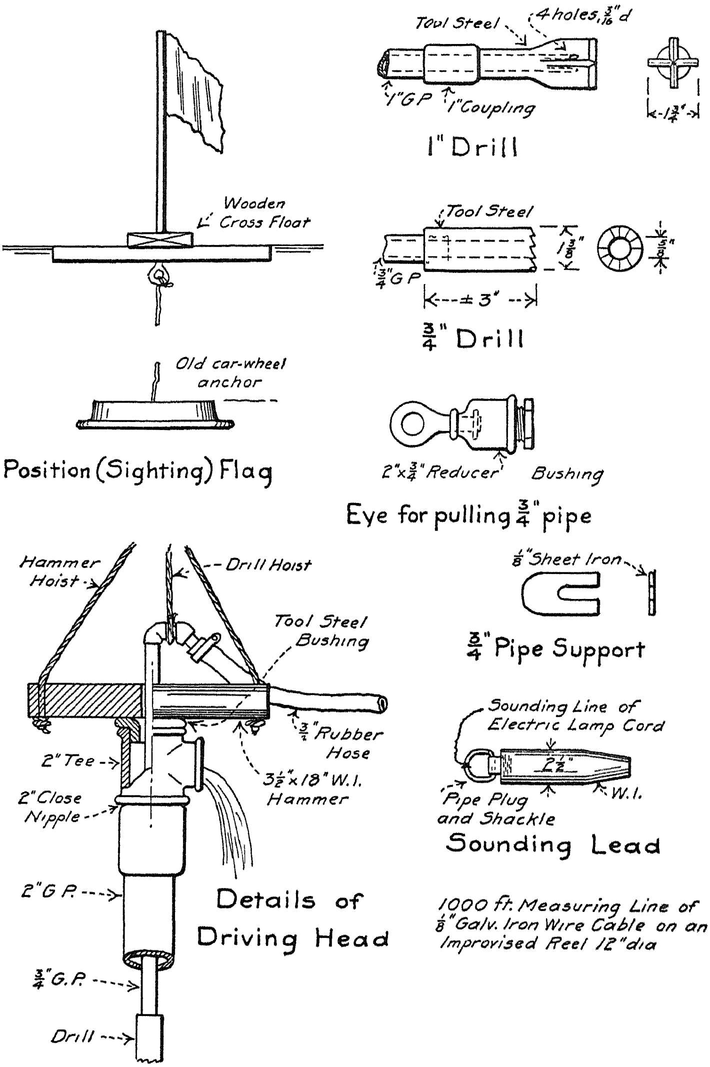


Fig. 6.—Details of boring rig.

and if the well is sunk much deeper, a smaller size must be used. In fine-textured, clayey or loamy material the hole may often be jetted down to the full depth required and the casing inserted afterward, for the wall of the hole becomes puddled by the muddy water and the vibration of the drill pipes against it, so that it will stand alone, like the wall of a well drilled by the hydraulic rotary method.

When drilling with a light rig, hard layers may be penetrated by using a drill bit on the drill pipe, and raising and dropping the pipe so as to strike blows as in the percussion methods. In this operation a blind valve is usually inserted in the drill pipe near its bottom to prevent drillings from entering and clogging the pipe. With a heavier rig, equipped with mast and hoisting sheave, a cable and small drill may be used for penetrating locally hardened layers that do not readily yield to the water jet.

A Boring Rig for River and Harbor Work

The rig described below was used for ascertaining the character of the bottom at a proposed wharf site in Hilo Bay, Hawaii. The bearing material sought was either hard lava rock or living coral, but the borings brought out the fact that this was obtained in some places only at a depth of about 80 ft., being overlaid with mud, so that a change in the original plans had to be made.

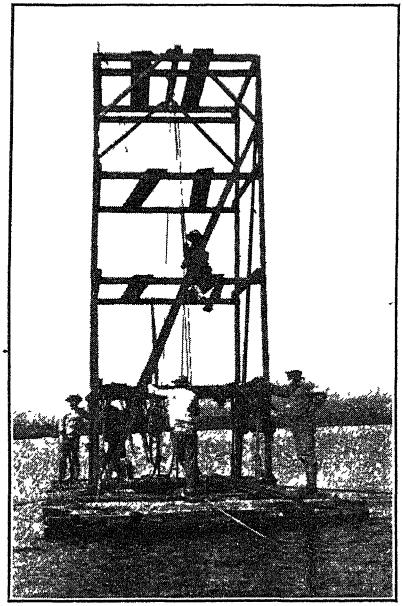


Fig. 7.—A boring rig for river and harbor work.

The rig was designed and the operations conducted by Mr. Wm.E. Rowell of Honolulu, T. H., who had had a large experience in similar work in such waters. It consisted of a light wooden tower 8 ft. square by 25 ft. high mounted centrally on a raft 12 ft. × 24 ft. over all. At the top of the tower was a cross-bar carrying a two-sheave pulley used to handle the pipe and tools, and openings in the floor permitted the sinking of the boring pipe. A shelf at one side of the tower carried the pipe tools, etc., and spare pipe was carried on the floor; also at one end of the raft was a small force-pump, with handles for one or two men to operate: the whole structure was very cheap and fulfilled its purpose admirably.

Details of the boring tools, etc., are shown in Fig. 6, and are self-explanatory.

The "sighting-flags" were located and set by triangulation in sufficient number so that a 1000-ft. measuring line would locate the raft at any time.

The raft was held in position by the anchors (regular 50-lb. type) with rough wooden buoys to show their position, a skiff being used to place the same.

When located, a length of 2-in. pipe was placed in position and forced down by hand to start, and then the hammer rig, 3/4-in. pipe, etc., fitted on, and hammering commenced; two men being sufficient to raise the hammer by means of a 7/8-in. diameter rope carried over block above.

When the 2-in. pipe refused to go any farther, the water was forced into the 3/4-in. pipe which was raised and dropped to cut away the material inside the large pipe. The waste-water and cuttings were discharged through the tee, and could be collected and examined. When the outfit neared the water-level, the head was unrigged, additional lengths of pipe inserted, and the operation continued.

When hard material was reached and the 2-in. pipe refused to go any farther, the whole length was pulled up; and if the end of the 2-in. pipe was burred-up, it was simply cut off smooth and used again for future holes.

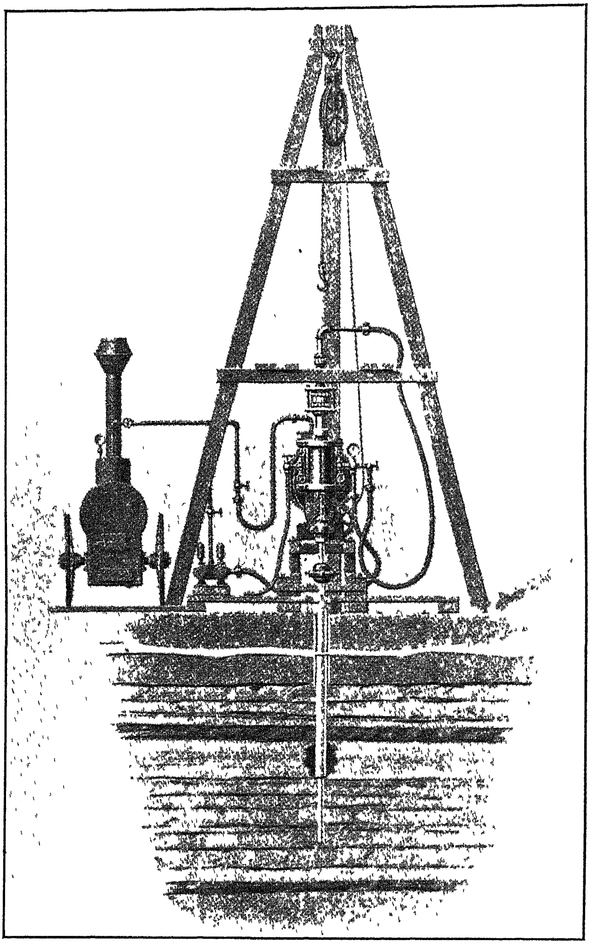


FIG. 8.—Arrangement of typical diamond drill outfit.

CORE DRILLING WITH DIAMOND DRILLS

The following description of diamond drilling machines and methods, and their applications, together with the accompanying cuts, is taken, by permission, from the catalog of the Sullivan Machinery Co., of Chicago, Ill., etc.

The **diamond drill consists of** a line of hollow rods screwed together in 5 or 10-ft sections, rotated by an engine through a shaft and gearing, and fed forward by either a hydraulic cylinder and piston or by a screw feed. At the

lower end of the rods is placed a bit, in which pieces of "black diamond" or carbon are set, and which, as the rods are rotated, cuts an annular hole in the rock, leaving a center piece or "core" undisturbed. Water is forced through the rods to keep the diamonds cool and to wash away the cuttings from the bit. The essential feature of this method is the core or section of rock, which is formed by the hollow bit and rod as the drill advances. At intervals, usually after drilling 10 ft., the rods are withdrawn by means of hoisting mechanism, bringing with them the rock core, which is caught and held by a self-locking "core lifter." The core is then removed, the rods again lowered, and the process repeated until the mineral body sought is found, or the desired depth reached.

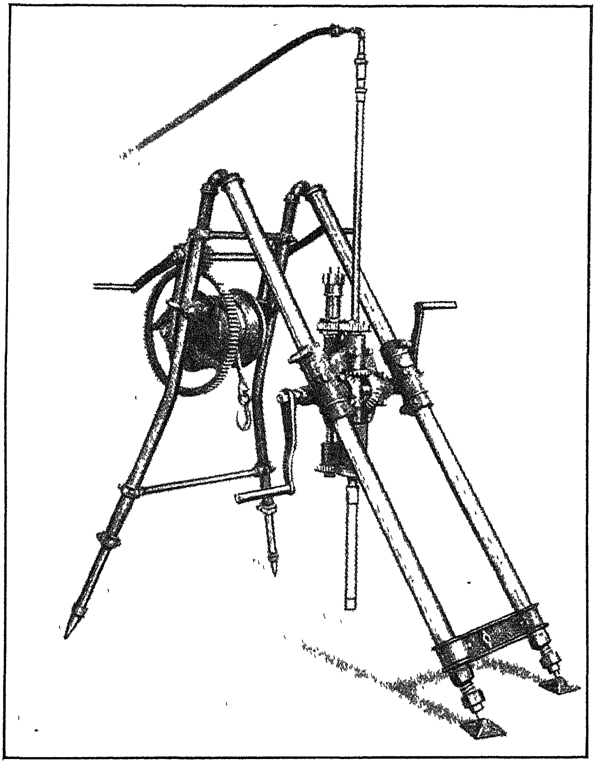


Fig. 9.—Sullivan class "M" hand power diamond drill. Capacity, 300 feet; diameter of core, 15/16 inch.

This method indicates to the prospector the exact depth of the ore body from the surface, and the thickness and character of the vein when found, as well as the nature of the material penetrated before reaching the vein. It is thus possible to estimate very closely the cost of development work, while the core of mineral furnishes accurate samples for assaying purposes. Of almost equal importance, if the mineral ore body is absent, the diamond drill indicates the fact, thus saving the cost of an exploratory shaft. The core may be preserved as a record, in boxes prepared for the purpose, each piece in its proper position as to depth. Such a record is one of the best arguments that may be used to induce capitalists to invest in mining enterprises.

In recent years the diamond drill has been used more and more generally by engineers and contractors **in testing foundations** for buildings, dams, heavy bridges, dry docks, etc., and for determining the materials to be encountered in the boring of tunnels for railway work, for sewers, and for water supplies. Owing to the fact that they may be operated as well through water as through the ground, they have been used extensively for the testing of materials for sub-marine foundations, and for borings along the lines of proposed subaqueous tunnels.

Diamond drill test borings have come to be considered almost indispensable in verifying the location of solid bed rock, suitable for such structures and undertakings; since the utmost reliance is accorded the evidence which their cores provide.

Drilling outfits are now available for operation by hand power, horse-power, by belt or gearing from a gasoline or oil engine or electric motor, or by steam or air power. Over thirty different styles and sizes of Sullivan drills are actually manufactured, in capacities ranging from 300 to 6,000 ft. in depth. Cores of various sizes may be extracted, although the capacity of the drill in depth

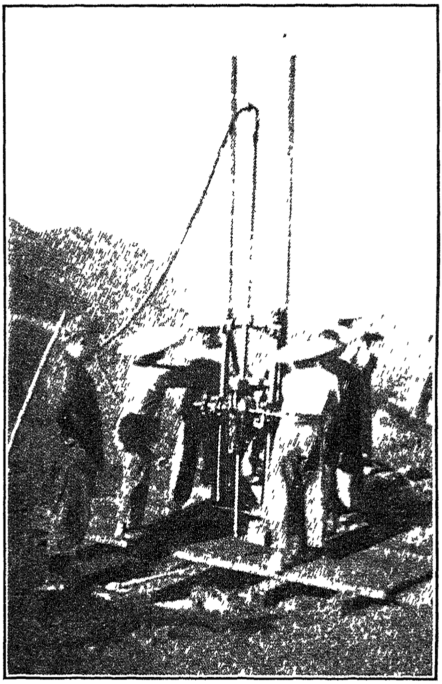


FIG. 10—Sullivan "Bravo" diamond drill operated by coolies, North China.

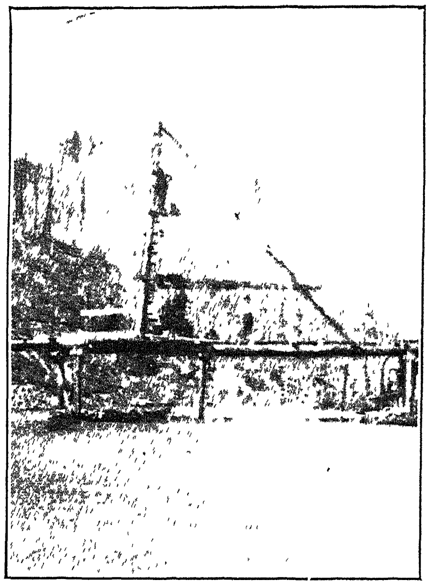


FIG. 11.—Sullivan core drill testing a water power site on the Sugar River, New Hampshire.

varies with the size of the core and of the hole bored. For ordinary prospecting work in hard mineral formations, up to a depth of 1,000 ft. a core 15/16 in. to 1 3/8 in. in diameter is sufficient for all purposes, while in coal, salt, and similar friable substances, the 1-in. core gives a perfect record.

The successful operation of the diamond drill and the results secured, naturally depend on the proper handling of the machine. The diamond drill, as a piece of mechanism, is simple enough, and any stationary engineer can operate it, as far as the work above ground is concerned. It is the knowledge of the action of the bit in varying formations which is so important, and this knowledge can be gained only by experience. This is a class of work in which the difference in the results obtained by trained and by inexperienced operators is very manifest. The formations often change suddenly from soft to hard, or from solid to loose and caving

ground, and when the bit is at work hundreds of feet below the surface, the operator should be able to tell at all times what the drill is doing. A skillful operator can avoid undue wear and breakage to his carbon, prevent the occurrence of costly delays, and maintain the highest possible drilling speed under all circumstances. The setting of diamonds in the bits also requires practice, and a knowledge of the best arrangement of the stones for various formations. It is, therefore, strongly recommended that when a drill is to be used by men unfamiliar with its operation, a skilled man be engaged, for a few weeks at least, to instruct the regular operators in the setting of bits and the care and handling of the drill.

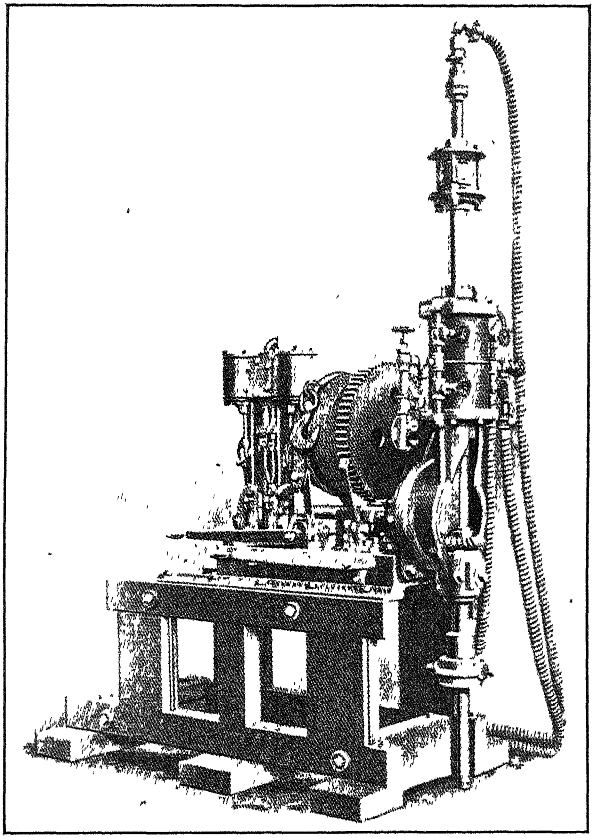


FIG. 12.—Sullivan "H-2" diamond core drill. Capacity, 1,000 feet. Diameter of core, 1 1/8 inches. This is the improved "H" drill, with internally geared hoisting drum.

The company's experience in conducting **engineers' test borings,** upon the proposed locations of bridges, dams, etc., has been particularly extensive during the last few years. Engineers have come to appreciate, with increasing force, the necessity of learning the exact location, nature and extent of foundation materials. This tendency has been fostered by notable failures, due to incomplete earlier data, so that the diamond drill, with its solid-core evidence, is often indispensable.

METHODS OF TESTING FOR BRIDGE FOUNDATIONS

The following discussion of this subject is taken from an article in "Engineering-Contracting" for Nov. 25, 1908, therein reprinted from "Mine and Quarry." The author is Mr. F. H. Bainbridge, Resident Engineer, Chicago and Northwestern Ry., Clinton, Iowa.

This article is confined to bridge foundations, although much of what follows is also applicable to foundations for buildings and hydraulic structures and preliminary examination for tunnel construction.

General Considerations.—Two methods of testing only are effective, an open pit or well for shallow foundations and the core drill for deep foundations. Sounding with gas-pipe rods in shallow foundations and the common well drill in deep foundations are not satisfactory. Fig. 13 shows two cross-sections of a stream at the same point, the dotted line being the line of supposed ledge rock as determined by a well drill operating a chopping bit; and the full line, the correct location of the ledge rock, determined with a Sullivan "HN" diamond core drill.

In general two sets of borings should be made for an important bridge crossing; the first set, a number of borings on the center line of the proposed location, to determine whether the site is a favorable one, and, if favorable, to determine by approximate estimate the most economical location of the piers and the length

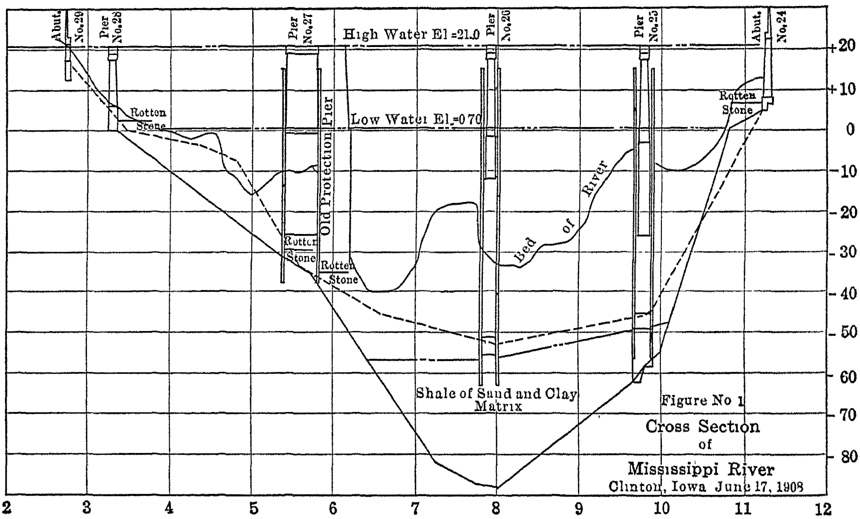


FIG. 13.—Two cross sections of stream at the same point.

of the spans. In a general way it may be assumed that the economical relation is reached when the cost of the substructure equals the cost of the superstructure; but inasmuch as the cost of the superstructure can be determined with considerable accuracy, while the cost of the substructure is involved in great uncertainty, the length of the spans selected should exceed that of the apparent economical relation. The length of spans chosen may also be influenced by other than economical considerations, such as government requirements, or the liability of ice to gorge against the bridge.

Having made a tentative location of the piers, borings should be made at each pier, and in the case of pneumatic or open dredged caisson foundations, one boring should be put down at each of the four corners of the caisson.

The preliminary borings may often be dispensed with when there are well records on both sides of the river in the vicinity. These well records can almost always be found in the various state geological reports, which can be had at any public library in the state. In case of the borings at Pierre, South Dakota, to be described later, the well records were so good that borings to determine the length of the spans were not necessary.

In cases where pile foundations are feasible and the river bottom is firm enough to lay concrete on, no borings are necessary, the required length of piling being best determined by driving experimental piles; but where the river bottom is soft, as it is in most streams with a sluggish or reversing current, borings should be made, the softer material being taken out dry with a sawtooth bit. This is feasible in the hardest clay or the softer shales and gives a perfect knowledge of the material encountered. Unless dry cores are taken when feasible, a hard clay in every way suitable for a foundation may be overlooked and provision made for carrying the foundation farther down than necessary.

Value of Borings.—In pneumatic work an accurate set of borings with a core drill is of incalculable value. These advantages are:

(1) The final location of the caisson can be accurately determined and cut stone and timber ordered without any waste or delay waiting for material for which no provision has been made.

(2) The contractor in bidding on the work knows exactly what material is to be encountered, and will make a lower bid when there is no uncertainty. The difference in cost between handling in a caisson material which can be takeu out through the blow pipe and material which must be locked out in buckets is very great.

(3) The piers can be located in the most economical position. Often a change of a few feet in locating a pier may make a difference in cost of tens of thousands of dollars.

(4) Much can be learned as to the character of the foundation that cannot be learned from the interior of the caisson. In limestone formations subterranean caverns are common, and in both lime and sandstone formations overhanging subterranean cliffs are found. The existence of these can be determined with the drill, but cannot be learned from the interior of the caisson.

Interpreting the Borings.—Nearly the whole North American continent north of the Ohio River and east of the Missouri River has at various periods been covered with glacial drift; in fact, the Ohio and Missouri rivers were formed by glacial action. Below the recent alluvial deposits in a river bed in this district will be found glacial deposits of sand, gravel, clay, till, or boulders, sometimes all together in a heterogeneous mass. The extreme determined movement of the greatest glacial sheet was 1,500 miles. Boulders of granite from Canada and Minnesota were carried as far as Kansas and Missouri. One of the boulders in the river bed is therefore liable to be mistaken for ledge rock. Usually the character of the ledge rock can be learned from state surveys and samples secured from the outcrops, which are located in these surveys. When a core is obtained which can be identified as the same as ledge rock it may or may not be the actual ledge. If the core is granite or some older formation than the ledge rock, it is certain that a boulder has been reached. More recent rocks sometimes exist as pockets in earlier formations, so that a mere difference in the character of the rock from the bed rock is not conclusive evidence that bed rock has not been reached. When such a condition is liable to be found in any locality it will usually be mentioned in the state geological surveys. Boulders of granite and other hard rocks must be removed by placing sticks of dynamite at the bottom of the stand-pipe, withdrawing the pipe, and exploding with an electric battery. Boulders of softer rock can be cut up with the chopping bits and the casing driven through them.

As boulders are usually separated by a matrix of sand or clay, the drop of the rods and the wash will show them as boulders and not bed rock in most cases, though this is not always conclusive, as pockets sometimes filled with sand are common in limestone ledges.

No definite rules can be given to cover all cases, and it is best, especially where there is any uncertainty, to put down a hole at each of the four corners of a pier. Where the drill strikes first rotten or sap rock, gradually increasing in hardness until known ledge rock is reached, this is conclusive evidence of bed rock. It is best to take out very soft, rotten rock with a sawtooth bit working dry.

Pierre, South Dakota, Work.—Drill tests for the foundations of the Chicago and Northwestern Railway bridge across the Missouri River at Pierre, South Dakota, were begun in December, 1905. The drill used was a Sullivan Machinery Company's "HN" diamond drill, operating 2-in. core bits; 4 1/2-in. stand-pipe and 3-in. casing, both with flush joints, were used. Borings at the sites of the river piers were made from the ice. In general four holes were put down at the site of each pier. On diagonally opposite corners holes were put down to about 90 ft. below low water, and on the other two corners to 60 ft. below low water. Thirty-three holes in all were put down, aggregating a length below the river bed or ground level of 2,379 ft., of which 1,456 ft. was in sand, gravel, and boulders, and 923 ft. in shale, with occasional small lenticular pieces of limestone. On the east or left bank heavy beds of glacial drifts were encountered and there was some difficulty in putting down stand-pipe and casing. The boulders were broken up with dynamite. In shale, sawtooth bits were used entirely, the bortz bit being used only in the limestone pockets.

Drilling at Clinton, Iowa.—In 1908 the Northwestern Railway began tests to locate suitable foundations for a new bridge over the Mississippi River at Clinton, Iowa. The same apparatus, tools, piping, etc., were used as at Pierre, but the manner of working and the materials encountered were essentially different. These borings were started in April, and it became necessary to mount the drill on a scow. Fig. 2 on this page shows the drill mounted ready for work. The scow was 15 ft. wide, 32 ft. long on the bottom and 37 ft. long on top, with a draft of 16 in. when loaded. Experience in rough water showed that a scow 10 ft. longer on top with somewhat more rake to the ends would have been more serviceable. The tripod consisted of three pieces of Douglas fir, 5 by 8 in. and 32 ft. long. An 8-in. wrought-iron pipe near the center of the scow, bolted with a pipe flange to the bottom of the scow, made a well for passing the stand-pipe 4 1/2 in. in diameter, and the casing 3 in. in diameter.

SEC. II. QUANTITATIVE FOUNDATION TESTING

Soil-testing Rigs

Figs. 14 and 15 illustrate suggestions for appliances for ascertaining the bearing power of foundation soils. The weight of platform, etc., should be ascertained before rigging up, by calculation or by actual weighing. With the rig shown in Fig. 15 all weights may be calculated and no scale is necessary, the tank being first properly calibrated.

The loading material for Fig. 14 may be pig iron, rails, bricks, stones, or (if a box be built) sand, etc., each added batch being weighed on a platform or other scale.

In place of the level shown in Fig. 15 for measuring the settlement,

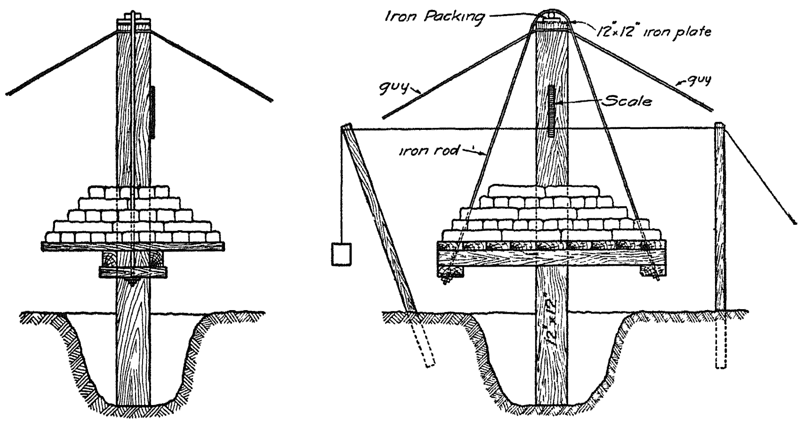


FIG. 14.—Soil-testing rig.

a stretched string or wire as shown in Fig. 14 may be used, or a straightedge conveniently supported.

Another type of rig for soil-testing that can be very easily constructed consists of a rectangular platform built on four legs. Care should of

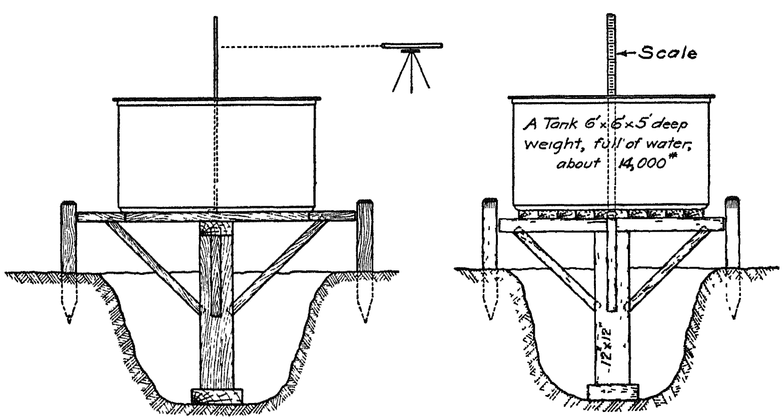


FIG. 15.—Soil-testing rig.

course be taken to see that each post is equally loaded, and settlement should be measured for each post. This method would seem to be adaptable only where tests are to be made at small depths; the use of a large tank for water loading would ensure equally distributed pressure.

Soil Testing at Greater Depths

In the *Eng. Record* of July 16, 1910, is given a description of a test conducted at a depth of 35 ft. below curb-level, in N. Y. City, and under cramped working conditions. The method used is here epitomized for its suggestive value.

A 16-in. W. I. pipe in about 7-ft. lengths was sunk about 35 ft. below curb-line by means of a small steam-hammer and a 1-in. water-jet pipe with a 3/8-in. nozzle. Obstructions of timber and boulders were disposed of by small dynamite charges. The outside couplings were found to be an obstruction. Inside was placed a 10-in. W. I. pipe, having at its lower end a ribbed cast-iron disk of 154 sq. in. net area, with a 1 1/2-in. hole in the centre. This was sunk by means of the jet to 9 in. below the 16-in. pipe, and was centred in it by spacers. A platform was then constructed at the top of the 10-in. pipe (which projected 10 ft. above the outer casing)

Load, tons	Date, appld.	Tons, sq ft	Settlement in inches							
			March 21	22	23	24	25	26	29	31
1	March 21	94	0							
5	March 21	4 66	$\frac{3}{32}$							
7	March 21	6 54	$\frac{3}{16}$							
9	March 21	8 4	$\frac{15}{32}$	$\frac{19}{32}$	$\frac{19}{32}$	$\frac{20}{32}$				
13	March 24	12 15				$1\frac{3}{32}$	$1\frac{4}{32}$	$1\frac{8}{32}$	$1\frac{8}{32}$	$1\frac{9}{32}$

Load, tons	Date, appld.	Tons, sq ft	Mar 31	April 1	2	4	5	6	7	8	9	10	12	13
17	March 31	15 9	$1\frac{20}{32}$	$1\frac{23}{32}$	$1\frac{26}{32}$	$1\frac{28}{32}$								
21	April 4	19.6				$2\frac{10}{32}$	$2\frac{18}{32}$	$2\frac{20}{32}$	$2\frac{22}{32}$					
25	April 7 . . .	23.3							$3\frac{1}{32}$	$3\frac{8}{32}$	$3\frac{10}{32}$	$3\frac{10}{32}$	$3\frac{10}{32}$	
29	April 13 . . .	27.1												$3\frac{15}{32}$

Fig. 16.—Record of Soil Test.

by clamping two pairs of 12 × 12-in. timber at right angles to one another just above the 16-in. pipe, and supporting them by 1-in. rods from their ends to a band bolted to the top of the pipe just above a coupling. The loading consisted of 1-ton blocks, which were handled by a differential hoist. The pipe and platform itself weighed about 1 ton. A reference mark was placed on the 10-in. pipe and a bench-mark established.

The results of the test given in the article are tabulated in Fig. 16.

The initial load of 1 ton is included. The Building Dept. inspected the test and allowed a load of 8 tons per square foot on the material

(sand). The ultimate load, as shown above, was about 27 tons per square foot (1:3.4).

The apparatus was invented by Mr. John F. O'Rourke, and the tests were made by the O'Rourke Engineering Construction Co.

Standard Tests of Soil, N. Y. Bldg. Code

Rules for making tests and fixing safe bearing pressures on soil as issued by the N. Y. Bldg. Dept. are given below.[1]

Of particular interest is the rule given from the relation of allowable, or safe pressure, to the final test pressure, and the method of defining the latter pressure.

In conducting tests to determine the safe sustaining power of the soil, as provided in Section 23 of the Building Code of New York, the following regulations will govern in the Borough of Manhattan hereafter·

(1) The soil shall be tested in one or more places as the conditions may determine or warrant, at the level at which it is proposed to place the bottom of the foundations of the structure.

(2) All tests shall be made under the supervision of the Superintendent of Buildings, or his representative.

(3) Each test shall be made so as to load the soil over an area of not less than 4 sq. ft. in any one place.

(4) Complete records of all tests and measurements shall be placed on file in the Bureau of Buildings.

(5) Before any test is made a sketch of the proposed apparatus and structure to be used in making the test must be submitted to the Superintendent of Buildings for approval.

(6) The accepted safe load shall not exceed two-thirds of the final test load

(7) The loading of the soil shall proceed as follows:

(a) The load per square foot which it is proposed to impose upon the soil shall be first applied and allowed to remain for at least 48 hours undisturbed, measurements or readings being taken once each 24 hours or oftener in order to determine the settlement, if any.

(b) After the expiration of the 48 hours the additional 50 percent excess load shall be applied and the total load allowed to remain undisturbed for a period of at least 6 days, careful measurements and readings being taken once in 24 hours, or oftener, in order to determine the settlement.

(8) The test shall not be considered satisfactory or the result acceptable unless the proposed safe load shows no appreciable settlement for at least 2 days and the total test load shows no settlement for at least 4 days.

Rudolph P. Miller,
Supt. of Buildings.

New York.

Miscellaneous Notes on Soil Testing

Interpretation of Foundation Tests.—Kidder, in his "Architects and Builders Pocket Book," gives the rule that from one-fifth to one-half

[1] *Eng. Rec*, July 27, 1912.

the load required to produce settlement will give the safe load, according to circumstances.

The regulations of the **New York Building Code** allow a safe load not exceeding two-thirds the final test load, a ratio of 1:1.5. (See p. 21.)

From "American Civil Engineers' P. B.," 2nd Ed., p. 526:

"In the case of the **Congressional Library,** Washington, D. C., the ultimate supporting power of "yellow clay mixed with sand" was 13 1/2 short tons per square foot, and the safe load was assumed to be 2 1/2 short tons per square foot." (A ratio of 1:5.4, Auth.)

"From the experiments made in connection with the construction of the **capitol at Albany, N. Y.,** the conclusion was drawn that the extreme supporting power of that soil was less than 6 tons per square foot and the load which might be safely imposed upon it was 2 short tons per square foot. (A ratio of 1:3, Auth.) The soil was blue clay containing from 60 to 90 percent of alumina, the remainder being fine siliceous sand. The soil contains from 27 to 43, usually about 40, percent of water, and various samples of it weighed from 81 to 101 lb. per cubic foot."

For a dense blue clay subsoil, on the site of the **Michigan Central Terminal, Detroit,**[1] a safe load of 4,000 lb. per square foot was adopted after tests showed that 5,500 lb. exceeded the safe capacity of the soil —a ratio of 1:1.38. In explanation of this small ratio, however, it should be stated that it was known that a satisfactory foundation could be designed within this loading; *i.e.*, the tests were confirmatory rather than exploratory.

On **soft material** the test post will sometimes **squeeze up the surrounding earth,** thus invalidating the results of the test. This may be obviated by back-filling around the post so as to maintain the original soil surcharge at the level of the post bottom.

The following observations on loading a test-post and interpreting the results are extracted from an article by **Mr. E. McCullough of Chicago, Ill.,** in *Eng. News* of Sept. 24, 1914, p. 648. The article is valuable, also, for a cut illustrating, in detail, a loading arrangement that has been used in a number of soil tests for building foundations.

"Elevation should be read after loading, and 6 hours later. The readings should be plotted and if the curve is a decided parabola the test load may be left until no settlement occurs. If after 18 hours the curve shows no sign of being a decided parabola, the test load should be lightened. One-fourth of the test load which the post can carry for 24 hours without settlement should be a safe load per square foot. The settlement during the loading of the platform may be several inches, due to unavoidable rocking of the test arrangement, but this should be ignored and only the settlement occurring after the full load is applied should be considered."

[1] See description and reference, p. 24.

Indicating Soil Test Results by Curves.—Fig. 17[1] shows the results of two soil tests in graphical form.

A study of the curves (of two separate tests) will show that the heavy lines are ideal curves drawn between the points of the "actual settlement curves" which are shown in light dashes. Fig. 18 shows the relative values of various strata at the location of test, and indicates very clearly that the sandy strata are by far the best in bearing value. The location of the "yield point" on the curve is instructive, but the article does not state what was the assumed safe bearing value of the soil selected.

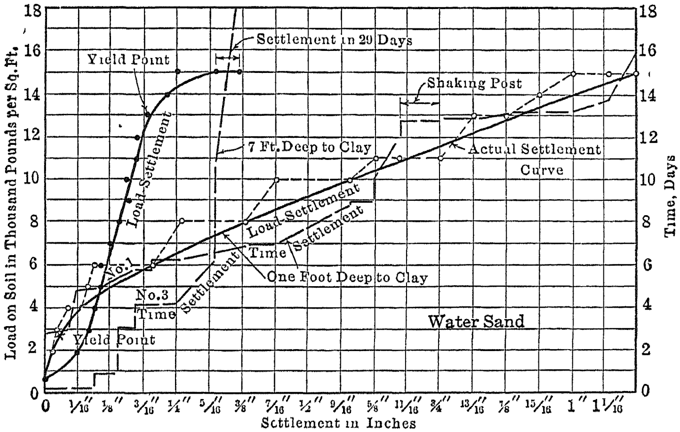


FIG. 17.—Graphical record of soil tests.

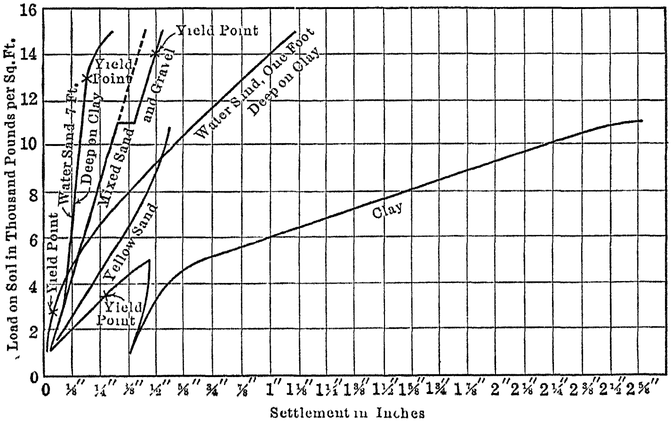


FIG. 18.—Comparison of settlement curves.

Alternate Methods.—The following **directions for testing** are abridged from Patton's "Treatise on Civil Engineering." Dig pits 2, 4, 6 and

[1] *Eng News*, May 7, 1914, p. 1025; article by M. W. Manz.

8 ft. deep, and test with a 12 × 12 timber in each. Observe by a level, or by a string or straight-edge across the face of the timber: (1) the least load that produces appreciable setting, (2) extent and rate of settling under this load, (3) effect of the continued application of this load. Make observations with increments of about 100 lb. For softer materials, increase size of base to 2, 3 or 4 sq. ft., for marshy soils up to 6 or 8 sq. ft. Note whether settlement produces: (1) compression, or, (2) bulging, by driving stakes in the surrounding material and noting the levels.

When the proposed structure is one subject to **vibrating loads,** this condition may be roughly anticipated in the test by strongly vibrating the loaded post from time to time and noting the increased settlement; the effect is illustrated in Fig. 17.[1]

In tests conducted[2] for the design of the **foundations of the Michigan Central Terminal at Detroit,** in a blue clay formation of varying texture, four different methods were employed, so as to obtain a comprehensive knowledge of the sub-surface conditions for this important structure. The first consisted in loading a platform 11 ft. square supported on four 12 × 12 in. square posts. The second device consisted of a single 12 × 12 in. post with a loading platform on top. All of these posts were in back-filled pits 5 ft. deep. The third test was conducted in a 7-ft. diameter sheathed well 19 ft. deep; the bearing plate was 2 ft. square, surmounted by a platform (at the bottom of the well) loaded with short pieces of rail: readings were taken on top of a 1 1/4-in. iron rod 18 ft. long, extending from the bearing plate to the surface through a piece of pipe to protect it from the loading material The fourth test was designed to approach more nearly actual load conditions, and consisted in loading a concrete pier 9 ft. 4 in. in diameter at the base reduced to 5 ft. in diameter at the top.

All the tests indicated substantially similar results, although the last showed smaller settlements than the others, giving finally a practically stable condition at a load of 5,500 lb. per square foot. A safe load of 4,000 lb. per square foot was accordingly adopted; or, rather, this proposed figure was demonstrated to be safe.

The article in question is of particular value on this subject, being well illustrated with cuts and curves.

For tests conducted in **St. Paul, Minn.,**[3] to determine the feasibility of the soil holding up a new 12-story building, under a load of 4 tons per square foot, a block 4 ft. square was used consisting of a 1-in. thick steel plate under a three-high layer of 12 × 12 × 48 in. timbers. This was placed in a sheathed pit 15 ft. deep, and the platform therein was

[1] *Eng. News*, May 7, 1914, p 1024.
[2] *Eng. News*, Oct. 1, 1914, p. 704.
[3] *Eng News*, Oct. 8, 1914, p. 736.

loaded with pig-iron: timber dollies, acting on vertical strips of wood, were used to prevent the load from tipping against the sides of the well. As a previous test with a 2-ft. square block had failed by reason of the material being displaced and forced up outside of the base, the remainder of the pit was covered with 2-in. planks weighted to 475 lb. per square foot to meet as nearly as possible the actual conditions that would exist were the building completed. A 1-in. pipe extended from the steel plate to the top of the pit to provide a bench on which to take levels. The soil was a mixture of coarse sand and comparatively small gravel with about 10 per cent. of clay; and, under a final load of 8 tons per square foot a total settlement of 1/4 in. was recorded.

SEC. III. STREAM GAUGING

Stream Gauging; Important Observation

The record of a stream gauging on some one day, without data as to its relation to other flows, is *worthless*, and is liable to lead to financial wreck if acted upon. The most important record is that taken at time of *lowest water*.

For important installations, gaugings are taken daily for as long a period as is necessary to give a record of maximum, minimum and average flow, so that fairly exact calculations may be made as to probable flow throughout the year.

If, however, it is only possible to submit the result of a single gauging, a report should be submitted, giving, as accurately and fully as possible, the relative flow to be expected at all other times of the year.

Stream Gauging by Cross-section and Velocity Method

The following method applies more particularly to small streams or rivers; for larger rivers or for more accurate methods see any of the standard text books on surveying or hydraulic engineering. It is not as accurate as the method of measuring by a weir described on p. 26.

Select a point in the stream having as uniform a cross-section as possible in the length to be gauged, from 50 ft. in slow streams to 150 ft. in swift ones. If necessary, remove sub-surface obstructions such as snags, weeds, rocks, etc., so that the bed of the stream may be fairly uniform in cross-section and free from obstructions that would vary the velocity of the float.

Obtain a cross-section of the stream at a place in the selected stretch where it remains tolerably uniform for some distance. This may be done by stretching across the stream a cord carrying tags at measured intervals, and measuring the depth at these points with a pole or sounding line, platting the results and calculating the area.

The velocity may be obtained by planting range poles (say one on each side of the river) at the upper end of the stretch and two at the lower, measuring the distance between these stations and observing, with a seconds watch, the time required for the float to traverse this distance. It should be noted that the distance to be measured is not necessarily the distance between the poles but the distance traversed by the float as sighted by the range poles. The float should be launched in the swiftest part of the current (point of maximum surface velocity) and some distance above the first range poles, so that it may have time to attain the velocity of the stream. The float may be a small block of wood or a weighted cork, painted so as to be easily visible. Several tests should be made and the mean result taken; also the tests should be made in perfectly calm weather so that the velocity of the float may not be affected by the wind.

The velocity thus measured will be the maximum surface velocity and should be multiplied by .8 to obtain the approximate *mean velocity.*

The mean velocity (in feet per second) multiplied by the area of cross-section of the stream (in square feet) will give the discharge of the stream (in cubic feet per second).

Stream Gauging by Means of a Weir

This method of measuring the flow of water in streams, discharge from pumps, etc., when carefully executed, gives very accurate results. Refinements of calculation dependent on variations in conditions are not here considered; see text books on hydraulics or experimental engineering for more exact methods.

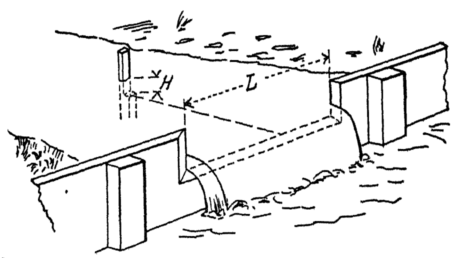


Fig. 19.—Stream gauging by means of a weir.

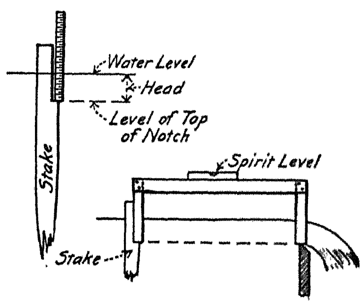


Fig. 20.—Measuring the head.

The **apparatus** is illustrated in the accompanying figures.

The **conditions affecting the accuracy** of the weir are as follows:[1]

(1) The weir must be preceded by a straight channel of constant cross-section, with its axis passing through the middle of the weir and perpendicular to

[1] Carpenter's "Experimental Engineering."

it, of sufficient length to secure uniform velocity without internal agitation or eddies.

(2) The opening itself must have a sharp edge on the up-stream face, and the walls cut away so that the thickness shall not exceed one-tenth the depth of the overflow.

(3) The distance of the sill or bottom of the weir from the bottom of the canal shall be at least three times the depth on the weir, and the ends of the sill must be at least twice the depth on the weir from the sides of the canal.

(4) The length of the weir perpendicular to the current shall be three or four times the depth of the water.

(5) The velocity of approach must be small; for small weirs it should be less than 6 in. per second. This requires the channel of approach to be much longer than the weir opening.

(6) The layer of falling water should be perfectly free from the walls below the weir, in order that air may freely circulate underneath.

(7) The depth of the water should be measured with accuracy, at a point back from the weir unaffected by the suction of the flow and by the action of waves or winds.

(8) The sill should be horizontal, the plane of the notch vertical.

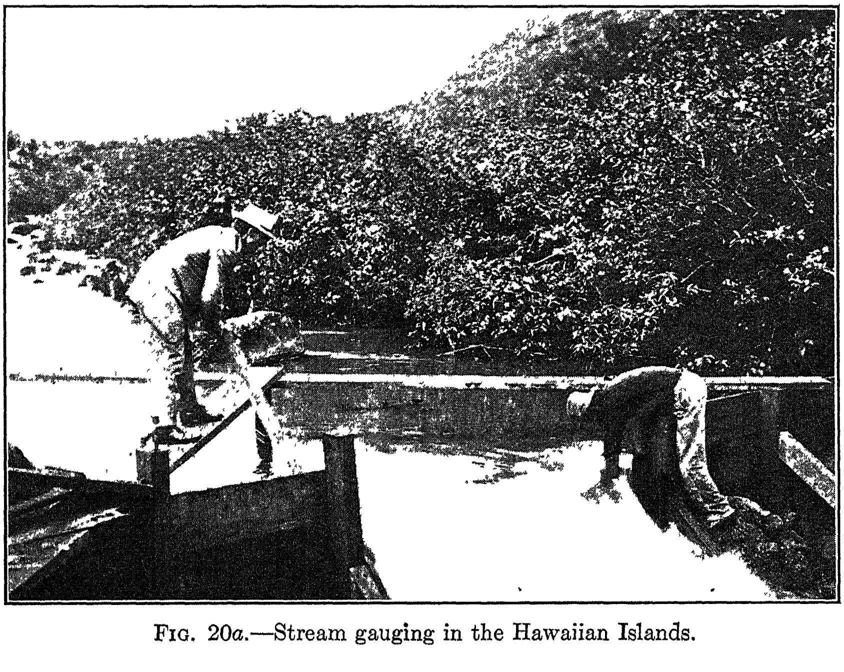


FIG. 20*a*.—Stream gauging in the Hawaiian Islands.

To reiterate, it is very important in making a measurement that the level of the notch or sill of the weir *be exactly horizontal* and that the *head* of water be measured with the greatest exactness.

Methods of Measuring the Head.—The head may be measured by readings on a stake, by a hook gauge or by floats. In any case the

measurement should be made far enough back from the weir so that the level will be unaffected by the flow.

A suggestion for setting a **stake** and reading therefrom is shown in Fig. 20. The leveling board should be perfectly true on top and the legs of exactly equal length, and the stake should be driven until the shoulder on it is at the same level as the top of the notch as shown by the spirit level. Or the same result may be obtained with an engineer's level and rod, if available. Or the stake may be driven so that the shoulder is at the water-level at the moment that the rising water just reaches the level of the notch; this method, however, is affected by capillary action at the crest.

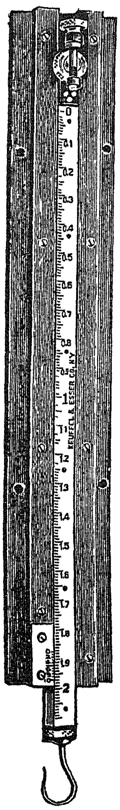


FIG. 21.—Hook-gauge.

The **hook gauge** (Fig. 21) offers the most accurate method of measuring the head. It consists of a scale 2 ft. long graduated to 100ths ft. and sliding in the groove of a frame which also carries an adjustable vernier reading 1000ths ft. By means of this adjustable vernier the scale can be set to read exactly zero when the tip of the hook is level with the crest of the weir and all readings can be taken directly without the necessity of making a correction for initial reading. The lower end of slide is fitted with a movable brass hook, upper end with a micrometer screw.

It is secured to a stake driven into the stream, and readings are obtained by moving the slide *up* until the point of the hook just makes a "pimple" on the surface of the water.

Floats[1] are sometimes used; they are made of hollow metallic vessels, or painted blocks of wood or cork, and carry a vertical stem; on the stem is an index-hand or pointer that moves over a graduated scale.

Computation of Results.—The following table[2] gives the discharge in cubic feet per second for each foot in length of weir such as is described above. It gives very approximate results also when there is end contraction (sides boarded), provided that L is at least = 10 H and but about 6 percent in excess of the truth if L = 4 H. (in contracted weir).

Example.—For a weir 5 ft. 0 in. wide, and a head of .74 ft., the discharge will be 2.120 × 5 = 10.6 cu. ft. per second.

To obtain the discharge in U. S. gallons per minute, multiply the above result by 448.831, or 10.6 × 448.83 = 4757.6 gallons per minute.

[1] Carpenter's "Experimental Engineering."
[2] Taken, by permission, from Trautwine's "Civil Engineer's Pocket-Book."

Table I.—Weir Discharges

Head, H, in ft	Cu ft per sec.	Head, H, in ft	Cu ft per sec.	Head, H, in ft	Cu ft per sec.	Head, H, in ft	Cu ft per sec	Head, H, in ft	Cu ft per sec
.01	0 003	51	1 213	1 01	3 380	1 51	6 179	2 01	9 489
02	0.009	.52	1.249	1 02	3 430	1 52	6 240	2 02	9 560
03	0 017	53	1 285	1 03	3 481	1 53	6 302	2 03	9 631
04	0 027	54	1 321	1 04	3 532	1 54	6 364	2 04	9 703
05	0 037	55	1 358	1 05	3 583	1 55	6 426	2 05	9 774
06	0.049	56	1 395	1 06	3 634	1 56	6 488	2 06	9 846
07	0 062	57	1 433	1 07	3 686	1 57	6 551	2 07	9 917
.08	0 075	.58	1 471	1 08	3 737	1 58	6 613	2 08	9 989
09	0 090	59	1 509	1 09	3 790	1 59	6 676	2 09	10 062
10	0 105	.60	1 548	1 10	3 842	1 60	6 739	2 10	10 134
11	0 121	.61	1 586	1 11	3 894	1 61	6 803	2 11	10 206
12	0 138	.62	1 626	1.12	3 947	1 62	6 866	2 12	10 279
13	0 156	63	1 665	1 13	4 000	1 63	6 930	2 13	10 352
.14	0.174	.64	1 705	1 14	4.053	1 64	6 994	2 14	10 425
.15	0 193	.65	1 745	1 15	4 107	1 65	7 058	2 15	10 498
16	0 213	66	1 786	1 16	4 160	1.66	7 122	2 16	10 571
17	0 233	67	1 826	1 17	4 214	1 67	7.187	2 17	10 645
18	0 254	68	1 867	1 18	4 268	1 68	7 251	2 18	10 718
.19	0 276	.69	1 909	1.19	4 323	1 69	7 316	2.19	10 792
.20	0 298	.70	1 950	1 20	4 377	1 70	7.381	2 20	10 866
.21	0 320	.71	1 992	1.21	4 432	1 71	7 446	2 21	10 940
22	0 344	.72	2 034	1 22	4 487	1 72	7 512	2 22	11 015
23	0 367	.73	2 077	1 23	4 543	1 73	7 577	2.23	11.089
24	0 392	.74	2 120	1 24	4 598	1 74	7 643	2 24	11.164
.25	0 416	.75	2 163	1 25	4 654	1 75	7 709	2 25	11 239
26	0 441	.76	2 206	1 26	4 710	1 76	7 775	2 26	11 314
.27	0 467	77	2 250	1 27	4 766	1 77	7 842	2 27	11.389
.28	0 493	.78	2 294	1 28	4 822	1 78	7 908	2 28	11.464
.29	0 520	79	2 338	1.29	4 879	1 79	7.975	2 29	11.540
.30	0 547	80	2 383	1 30	4 936	1 80	8 042	2 30	11 615
.31	0 575	81	2 428	1 31	4 993	1 81	8 109	2 31	11.691
.32	0 603	82	2 473	1 32	5 050	1 82	8 176	2 32	11 767
.33	0 631	83	2.518	1 33	5 108	1 83	8 244	2 33	11 843
34	0.660	84	2 564	1 34	5 165	1 84	8 311	2 34	11 920
.35	0 690	.85	2 610	1 35	5 223	1 85	8 379	2.35	11.996
.36	0 719	86	2 656	1 36	5.281	1 86	8 447	2 36	12 073
37	0 749	.87	2.702	1 37	5 340	1.87	8 515	2 37	12 150
38	0 780	88	2 749	1.38	5 398	1 88	8 584	2 38	12.227
.39	0 811	.89	2,796	1 39	5.457	1.89	8 652	2 39	12.304
40	0 842	90	2.843	1.40	5 516	1 90	8 721	2.40	12.381
.41	0 874	.91	2 891	1 41	5 575	1 91	8 790	2 41	12.459
.42	0 906	92	2 939	1 42	5 635	1 92	8 859	2.42	12.536
.43	0.939	93	2 987	1 43	5.694	1 93	8 929	2 43	12 614
.44	0 972	94	3 035	1 44	5 754	1 94	8.998	2 44	12 692
.45	1 005	.95	3 083	1 45	5.814	1 95	9.068	2.45	12 770
.46	1.039	.96	3.132	1 46	5 875	1 96	9.138	2 46	12 848
.47	1 073	97	3 181	1 47	5 935	1 97	9.208	2 47	12 927
.48	1.107	.98	3.231	1 48	5 996	1 98	9 278	2.48	13 005
.49	1 142	.99	3 280	1 49	6 057	1 99	9 348	2 49	13 084
.50	1 177	1.00	3 330	1 50	6 118	2.00	9 419	2 50	13 163

SEC. IV. INFORMATION TO BE SUPPLIED FOR OBTAINING DESIGNS AND ESTIMATES

Steel Railroad or Highway Bridge; Information to be Supplied for Obtaining Designs and Estimates

It is supposed that a railroad company, a municipality or promoters desire designs and estimates for a bridge to cross a certain valley. The following clauses outline the data that should be submitted to the engineers or bridge companies in order that estimates may be figured as closely as possible and be obtained with the least delay and previous correspondence.

It is presupposed that, on structures of any importance at least, this information will be collected and submitted by an engineer. The comparison of the designs and bids, even for the smaller structures, must, by all means, be passed on by an engineer. The author recently had submitted to him, from a not obscure bridge company, a design for a highway span that made no pretense whatever of complying with the specifications imposed. The bridge was intended for export, and the manufacturer was evidently under the impression that no engineer would pass on the plans submitted to the agents handling the business.

The clauses refer principally to the superstructure, and are intended for aid in obtaining bids on that part only. However, an extended consideration of clause (30) by the contractor or his agent in person, will enable bids to be obtained on the substructure also.

Railroad Bridge

(1) Is track to be standard (4 ft. 8 1/2 in.) or narrow **gauge**? If the latter, give dimension.

(2) Is bridge to be for a **single- or double-track** railroad? If single, is provision to be made for future double-tracking?

(3) Under what **specifications** is the bridge to be designed? (Cooper's, Waddell's, American Maintenance of Way, etc., or Special Specifications.)

(4) If **exceptions** are to be made to any clauses in the specifications, indicate fully.

(5) Give engine and train **loading** for which bridge is to be designed. Are one or two engines to precede the train?

(6) If railroad is narrow gauge, submit a **clearance diagram.** If narrow gauge and double track, give distance centre to centre of tracks.

(7) Is any account to be taken in designing the bridge of a **future increase** in size and weight of rolling-stock? If not covered by any clause in the specifications or in the assumed live load, indicate the requirements definitely.

(8) Submit a blue-print of the **profile and plan** of the crossing to a convenient scale, showing all the information derived from the consideration of Clauses (9) to (11), etc.

(9) If bridge is to be placed on **old piers or abutments,** give complete dimensions on drawing.

(10) Is **grade** at crossing level or rising? Indicate on profile, giving elevation of

base of rail with reference to other elevations, and giving points of rise, and amount of same in percent or feet per mile.

(11) Is **alignment** at crossing tangent or curved? If the latter, indicate on plan points of curvature, degree of curve, length and alignment of spiral, etc.

(12) Consider **general** clauses (26) to (43).

Highway Bridge

(13) Clear width of **roadway**? Are outside **sidewalks** to be on one side or bridge only or on both? If the former, indicate side required on plan. Clear width of sidewalks?

(14) Is bridge to carry **trolley tracks?** Single or double track? If single, is any provision to be made for future double-tracking?

(15) Under what **specifications** is the bridge to be designed?

(16) If **exceptions** are to be made to any clauses in the specifications, indicate fully.

(17) **Live Load.**—Specify a class of loading as given in Cooper's General Specifications for Steel Highway and Electric Railway Bridges and Viaducts; or, give in detail the road-roller, street car, or other concentrated load to be carried with an additional distributed live load per square foot of unoccupied surface; and an alternate uniformly distributed live load (per lineal foot of bridge).

(18) Any special requirements as to **headroom?**

(19) Is any account to be taken in designing the bridge of a **future increase** in size and weight of rolling load? If not covered by any clause in the specifications or in the assumed live load, indicate the requirements definitely.

(20) **Floor.**—Are floor-joists to be of steel or wood? Are stringers for carrying street-car tracks to be of steel or wood? What construction will be used for floor; wood planking, macadam on R. C. floor slabs, macadam on steel buckle-plates, etc.? Describe fully so that calculations may be made of dead load. If R. C. floor slabs are to be used, is the manufacturer to furnish the reinforcing metal?

(21) **Sidewalks.**—Describe construction as outlined above for floors.

(22) Submit a blueprint of the **profile and plan** of the crossing to a convenient scale, showing all the information derived from the consideration of Clauses (23), (24), etc.

(23) If bridge is to be built on **old piers or abutments,** give complete dimensions on the drawing.

(24) Is **grade** at crossing level or rising? For bridges of several spans with rising grade, indicate on profile, line of top-of-rail of street-car tracks with reference to other elevations; if there are no car tracks, indicate surface of roadway at centre.

(25) Consider **general** clauses (26) to (43).

General Clauses, for both Railroad and Highway Bridges

(26) Will crossing be **"square"** or **"skew"**? If the latter, indicate angle on plan.

(27) Indicate on profile and give elevations for points of high and low water and flood heights; describe **character of stream,** whether an estuary, fresh-water river, mountain stream, etc., especially with reference to velocity, floods, scour, character and extent of drift, etc.

(28) Is stream navigable, so that a **draw-span** may be required? Indicate clear width and headroom to be preserved, either as required by the traffic or as imposed by the War Dept. or other authority. State whether opening of bridge will be frequent, requiring first class equipment; or practically negligible. What power will be used for operating, hand, steam, gas-engine or electric? In case of electric, state whether D.C. or A.C., voltage, phase and frequency (for A.C).

(29) Indicate character of **surface soil** over whole profile. If surface is very irregular, so that piers for trestles (for instance) for the same bent will be at different elevations, give contour lines at about 5 ft. elevations on plan view so that heights of tops or piers may be determined.

(30) Determine and note on profile drawing, character of probable (or possible) **foundation surfaces** for the whole area of crossing, digging pits or making borings as may be necessary. If the footings are to be on rock, describe geological character, dip of strata, hardness, friability, influence of exposure to weather on reliability, etc. If the footing soil will be a clay, sand, gravel or mixture of these soils, describe texture of same, action of moisture on their reliability, exposure to scour, etc. If piers are liable to be started on a pile foundation, ascertain certainty of these being always wet, probable bearing capacity of piles (drive test piles if necessary), exposure to toredo or other similar animal destructive agency. Consider applicability of steel or concrete piles, concrete piers on pile foundation, steel cylinders filled with concrete, etc., etc.

If piers are to be built in a deep or swiftly running river, requiring pneumatic caissons or other works of considerable magnitude, the services of an expert should be secured, both to determine the feasibility of the crossing and the best method of accomplishing the same.

(31) Indicate on drawing the **location of highways,** railroad tracks, navigable waters. etc., that must be cleared by new structure, giving **clear headroom** required by each.

(32) State (if ascertainable at the time) whether **piers and abutments** will be of concrete or masonry.

(33) **Class of Structure;** *i.e.*, Trestle, Plate Girder Spans on Piers, Lattice Girders or Pin-connected Spans on Piers or Trestle Bents, Cantilever Structures, Arches, Draw-Spans (Plate-Girder or Trusses), etc., etc.

Notes.—The Class of structure to be erected will depend very largely on the completed first cost. This cost will be the combined costs of the completed substructure and of the completed superstructure. Inasmuch as (for a steel bridge) the substructure and superstructure will usually be let to different contractors, it is necessary that the engineers retain control over the design of the whole structure in order to preserve the most economical ratio between the costs of these two items. At the same time an opportunity should be given to the engineers of the bridge companies to submit their own most economical designs.

Therefore it will usually be incumbent on the engineers for the owners to arrive at a decision as to the outline of the structure, to indicate the same on the profile and to call for bids on this outline. Also, if any divergence is allowable, the steel contractor may be invited to submit prices on alternate designs of his own, which he should have no trouble in doing intelligently if all the information herein outlined is submitted to him.

In this way very close and satisfactory bids may usually be obtained with a minimum of delay.

(34) If **truss spans** are to be adopted, indicate whether pin-connected or riveted trusses are preferred (as affected by erection requirements, etc.).

(35) Is cost of **removing an old bridge** to be included in the estimate? Describe conditions fully, submitting photographs and drawings of existing structure.

(36) **Is traffic to be maintained** on old bridge during re-building? Discuss possibility of relocating line, either temporarily or permanently.

(37) Submit any municipal or other **ordinances** which will govern the appearance, class of structure, design, etc., of the proposed bridge.

(38) Will the bridge be in a locality such as to be especially subject to **rust,** etc., so that provision must be made for a minimum thickness of metal, etc.?
(39) **On which bank** will material be delivered?
(40) Method of **erection.** Determine as nearly as possible and state, method of erection that will be adopted: this will be affected by the usual considerations of character of site, cost of lumber, speed of erection desired, etc., etc.
(41) If piers are to be made of steel **screw-piles, sheet-steel cylinders,** etc., state whether this material is to be furnished by the bridge company, and submit particular information concerning length, location, character of bottom, etc.
(42) **For Export Work:** state any special limitations on weights and dimensions of individual pieces (see p. 373 *et. seq*); specify that erection marks be stamped on pieces with steel dies in addition to paint marks, that special colors of paint be used (for ease in segregation and identification), etc. See Chap. IX.
(43) In calling for **quotations,** follow outline on p. 213.

A Reinforced Concrete Bridge

The methods of obtaining designs and estimates on reinforced concrete work are so diverse that no attempt will be made to present a logical arrangement of preliminary-information clauses. It is believed, however, that the list is sufficiently complete so that the promoter, engineer, or bidder, by running over the same, may make a selection proper and necessary to his particular purpose.

(1) Consider the clauses of the outline given for a Steel **Railroad or Highway Bridge** on p. 30 *et seq.*, in their relation to the construction of one of Reinforced Concrete.
(2) Ascertain cost per barrel of **cement** delivered at site, or of hauling from nearest R. R. station to site.
(3) Cost per yard of suitable **sand, gravel and stone** delivered at site?
(4) Report on class of **lumber** locally available for form construction, its cost at site, and possible future disposal.
(5) Method and cost of hauling **reinforcing steel** from nearest R. R. station to site?
(6) Ditto, for concrete mixing **plant,** etc.
(7) Character of **labor** available locally for excavation work, form-building, concrete work, etc.; its efficiency and cost?
(8) Make a thorough examination of the site, making borings and test-pits, to ascertain the character and amount of **excavation** required.
(9) Report on material available for **back-filling.**
(10) What kind of **floor finish** is desired, both for roadway and sidewalks? How much of this is to be done by contractor?
(11) Describe severity of **frosts** that might delay concreting.

Information Sheet for Steel Frame Buildings for Export

In order to obtain a close price on any proposed building, and to obtain it with a minimum of delay and previous correspondence, it will add very materially to the certainty of obtaining these results if the prospective purchaser will submit definite information as to the kind of building he has in view.

The following questions have been compiled in order to indicate the data that should be furnished. For all except the very simplest

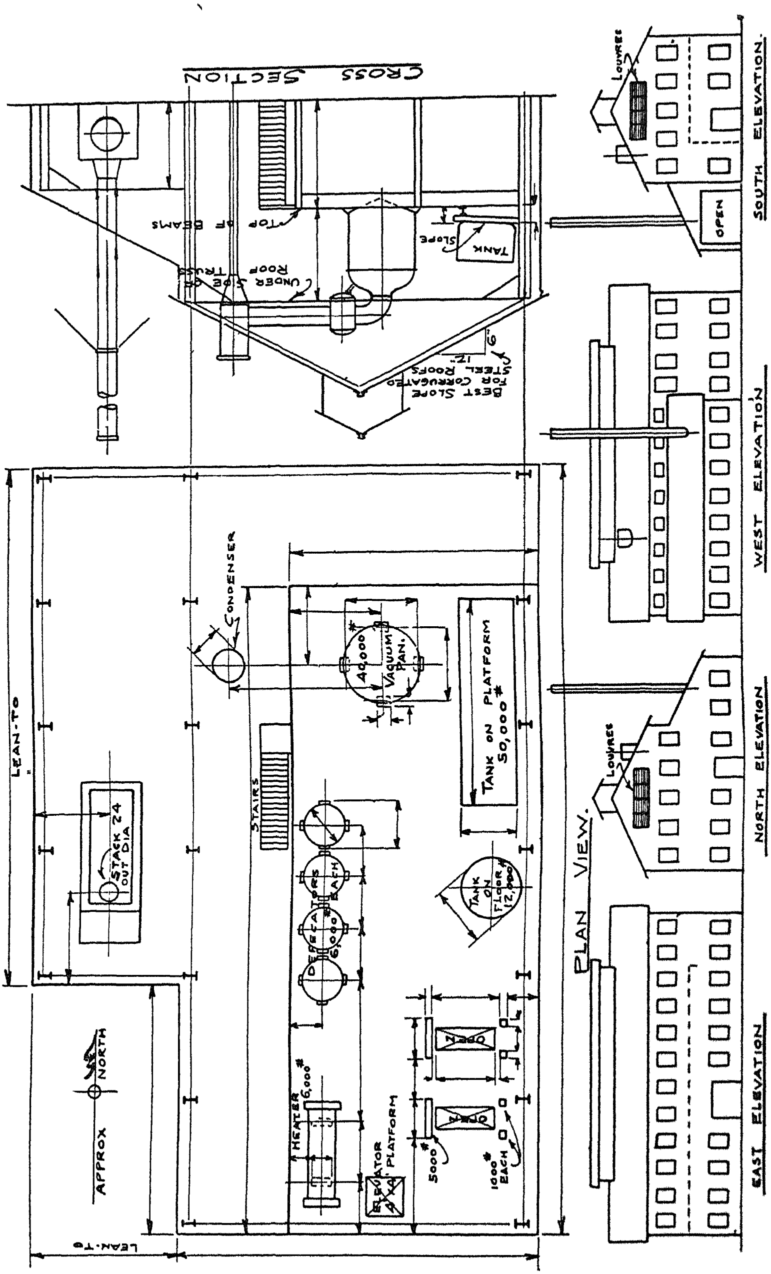


FIG. 22.—Typical drawing of factory building for obtaining prices. Also see Fig. 23.

buildings the information should be accompanied by a sketch made in about the style illustrated on Figs. 22 and 23 which accompany this

information sheet. It will be noted that a Floor Plan and a Cross-section are shown, and (to a smaller scale) Elevations of all sides of the building. On the Floor Plan should be located all machinery, tanks, etc., with their weights when in working order; and also the position of their feet or supporting lugs should be given so that beams to carry them may be properly located. The other views are self-explanatory.

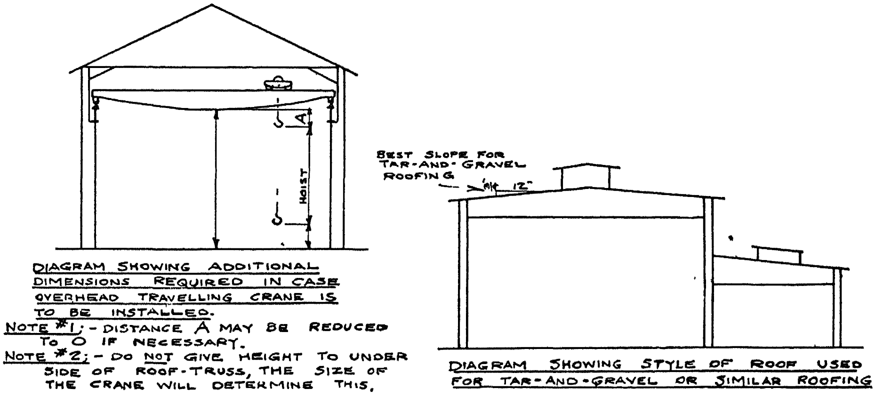


FIG. 23.—Factory building diagrams (see Fig. 22).

Main Dimensions

(1) **Width and length** of main building out-to-out?
Note.—Make allowance for space to be occupied by columns.

(2) Ditto, for lean-to's, etc.?

(3) **Height** to under side of roof-truss, for main building and for lean-to's.
Note.—Make allowance for knee-braces.

(4) **Upper Floors.**—Width and length, and height to top of steel beams? Note.—Make allowance for thickness of floor.

(5) **Traveling Crane.**—Distance to under side of bridge? Length of runway?

Floors

(6) Give working **weight of all machinery,** indicating on drawing the position of the supporting feet and lugs.

(7) Give size and location of all **openings** required in floor for the bottoms of machines, hoppers, etc.

(8) **Floor Loads.**—State whether floor will be used for storage purposes, giving the material to be stored and the probable height of the pile so that the floor may be designed to carry the load.

(9) State the **kind of flooring** desired, wood, concrete, steel-plate (checkered or indented), etc.

Roofs, Skylights, Etc.

(10) Of what material is the **roof** to be made; of corrugated steel (black or galvanized), give thickness or gauge of same; or tar-and-gravel on wood sheathing; or tile on steel purlins or on wood sheathing (in former case send a sketch of tile proposed); or other kind of roofing material?

(11) **Ventilators.**—Are these required? Are a number of round ventilators preferred or a long "monitor"?

(12) If a **monitor-ventilator** is required, is it to have slats (louvres) all around, or alternate slats and windows, or windows on one side (windward) and slats on the other side (leeward)?

(13) **Skylights.**—If these are required indicate their position on the drawing and give approximate size desired. Is a first-class skylight required (to go over a sugar-storage room, etc.), or one of ordinary construction?

(14) Indicate on the drawing the size and position of all **stacks, condensers,** etc., projecting through the roof, and state whether they are to be covered (with a small "pent-house") or not.

(15) Are **gutters** and down-spouts required to carry off the rain-water?

(16) Is it desired to use the **roof-trusses** for hoisting machinery? If so, state the approximate load that will come on each truss.

Siding, Windows, etc.

(17) Of what material are the **sides** to be composed; of corrugated steel (black or galvanized), give thickness or gauge of same; or of brick "curtain" walls in between the steel columns; or of brick "self-supporting" walls carrying the floors and roof; or of reinforced concrete; or of other material?

(18) **Windows.**—Indicate the number and position of the windows required on the sketch, and state approximately the size. If glass windows, are they to be fixed, or rising or pivoted? Or are iron-shutter windows preferred, or gratings (with or without glass windows)?

(19) **Doors.**—Indicate the number and position of the doors required on the sketch, and state approximate sizes. State whether they are to be metal-covered wood doors, or paneled, or of other type. Are sliding or swing doors preferred?

(20) Is the siding to extend up to the **eaves,** or is a space of 3 or 4 ft. to be left open for ventilation? Is it desired that this space be closed with wire-netting?

Miscellaneous

(21) Is the building to be of ordinary good **construction,** *i.e.*, with cornices, corner-boards, metal casing around windows and doors; or is it to be constructed as cheaply as possible, with all this finish omitted?

(22) **Stairs.**—Are these to be furnished? Note.—Steel channel stringers and metal treads are the usual construction; if wooden treads (furnished by purchaser) are desired it should be stated.

(23) **Railings.**—Are these to be furnished? Note.—Gas-pipe railings are the usual construction. Wooden railings should be furnished by the purchaser.

(24) **Elevator** (Freight and Passenger).—Is the elevator itself to be furnished? If so, state maximum and ordinary load to be lifted; approximate size of platform required; and whether it will be operated by a belt from a line-shaft, by a separate electric motor (give particulars as to current available); or by hydraulic power (give water pressure available). Also, is the elevator supporting frame-work to be of steel or wood? If of steel, is it to be furnished? Note.—Wooden framing is usually supplied by the purchaser.

(25) **Anchor-bolts.**—Are they to be furnished, or will they be made at the plantation from drawings supplied by the building contractor?

(26) **Traveling Crane.**—Is this to be furnished? If so, give capacity in pounds; whether hand power or electric (give all particulars as to current available); and give distance to underside of bridge and amount of hoist required (see sketch).

(27) Extraordinary **meteorological** or other conditions.—Will the building be ex-

posed to severe wind-storms, heavy falls of snow, earthquake shocks, etc.? State the severity expected in each case.

(28) **Shipment.**—Are there any limitations on the size or weight of the pieces entering into the structure on account of having to ship by mule-back, canoe, or other special means of transportation?

(29) In calling for **quotations,** follow outline on p. 213.

Coal, Etc., Storing and Handling Plant

Information to be given to engineers or to manufacturers of coal-handling equipment for obtaining a design and estimate.

(1) Submit a **plan of the site** to a convenient scale. Sections should be shown, taken on prominent lines, or the plan may be topographical.
Photographs of the site are usually very helpful. Show range of tide.

(2) State the character of the **material to be handled,** whether anthracite or bituminous coal, size of average and maximum pieces (in case of rock, etc.).

(3) Describe the **process of handling** that it desired to install; giving quantities in pounds or in tons of 2,000 or 2,240 lb. (be careful to state which) that are to be discharged, stored, recovered, loaded, etc., per hour or per day of 10, 12, 24, etc., hours (be careful to state which).

(4) In the case of **cars to be unloaded,** give the gauge of track, capacity of car, length of car inside, height to floor and top, whether side, end or bottom dump, etc.; sending, if possible a sketch of same. Give clearance requirements for locomotives.

(5) In the case of **boats to be unloaded,** give the net tonnage (capacity), length, size and location of hatches, etc., showing all on a plan and cross-sections of individual boats if possible, or describe the class of boats sufficiently so that the plant may be designed to suit them.

(6) In the case of cars, boats, **carts, etc., to be loaded,** give similar information to that described above.

(7) Describe the character of the surface-soil and **foundation-soil** sufficiently so that foundations may be properly designed. See p. 18; and, in case of questionable material, make tests as there described.

(8) In case a **wharf** is to be built, submit information as outlined on p. 48.

(9) What **power** is to be used, to operate the installation, steam or electric? In the former case describe any existing boiler-plant that it is proposed to use, sufficiently so that calculations may be made as to the power available. In the latter, state whether direct or alternating current is available, the voltage, and, for A.C., the phase and frequency; also state the power available.

(10) Is the **fixed structure** to be of wood, of structural steel, of reinforced concrete, or of a combined construction? Describe requirements for trestles, bins, etc.

(11) Are **moving towers** to be of steel or wood construction, or a combination?

(12) Are there any municipal, state or federal **regulations** as to headroom, clear waterways, boiler plants, etc., to be complied with?

(13) What are the local conditions as to skilled and unskilled **labor** required on construction or operation? Wages?

(14) What are the facilities for unloading and transporting **materials of construction?** Are customs duties, landing-charges, etc., to be figured on? If so, enumerate in full.

(15) In case the plant is to be contracted for **"erected",** submit data as to cost of cement, stone, sand, lumber, etc., to be used in construction; space available for storing material and rent for same; etc. Go over the whole process of

erection mentally, down to acceptance and payment, and obtain data and costs of all items that can possibly affect the job.

(16) **Meterological.**—What rains, storms, earthquakes, etc., may be expected during the construction or life of the structure, that must be provided for. In case of violent winds or hurricanes, state maximum velocity.

(17) In calling for **quotations,** follow outline on p. 213.

Electric Power Development: Information to be Submitted for Obtaining Designs and Estimates

I. The Market

A. Electric Light and Power

(1) Submit **Maps** of the area of proposed electrification, one on a small scale to show the whole district; and others, on larger scales, to show each town, etc. On these should be marked present **Population,** existing factories, probable future developments of population and **Industries,** etc., preferably in colors for quick grasping by non-technical consultants. Also indicate proposed sites of **power houses,** sub-stations, coal-storage sites, transmission lines, etc.

(2) Obtain as accurate data as possible concerning present **Population,** and its **Distribution.**—Report on probable increases. Submit unit figures as the work may warrant.

(3) Describe the character of **Dwellings** in the different areas, and report on the present means of lighting and cooking, its cost, and the disposition of the inhabitants to adopt electric light and devices.

(4) **Industries.**—Enumerate and describe existing industrial establishments, obtaining data regarding existing kind, quantity and cost of power; suitability of the work for electric driving; style of current and motors most suitable; use of current for electric furnace work, etc.

Also outline probable growth of present industries and possible development of new ones if suitable and cheap power is available.

(5) **Street Lighting.**—Present means of lighting; possibility of change to electric; franchise that may be obtained; style of lights preferred or best adapted to conditions (bearing in mind the combinations of a house-lighting service); total number required; restrictions on overhead wiring; "moonlight" or "all-night, every-night" service required; probable price per lamp per year that may be obtained; mark location of lamps on map so that wiring system may be estimated; preference of authorities regarding appearances of poles, lamp standards, overhead wiring, etc.; submit photos of typical streets; municipal ordinances governing installation; local material available for poles, etc.

B. Street and Interurban Railways

(6) Submit topographical **Maps,** of the whole district on a small scale and of the towns on a large scale. Outline in color areas particularly considered.

(7) Give the **Populations** of the effected and contiguous towns and villages and record on map. Describe the **commercial characteristics** of the districts, enumerating factories and number of persons employed in each, movement of farming produce and freight, etc., etc.

(8) Show on the map the proposed location of the **Lines,** and also possible future extensions. Indicate double tracks and turnouts.

(9) Discuss the matter of probable **Increase in Traffic.**

(10) Indicate on the map the location of **Ball-grounds, Parks, Cemeteries** and such other places as will call for a concentration of cars and power at special times.

(11) Number the different lines or parts of lines and state for each the desired frequency of **Car Service** during "rush hours," in daytime and at night; *i.e.*, submit tentative schedules.

(12) Note all **grades,** giving their length, gradient and direction. These may best be shown by **Profiles** made along the proposed routes.

(13) Describe present **Surface** of streets, whether stone paving, asphalt, etc. Is it proposed to put in a new surface when car lines are laid? What portion of expense of street paving is to be borne by the railway company?

(14) Are there any restrictions concerning overhead **Trolley Wires** or conductors? Are wood or metal poles to be used?

(15) State any preference as to **Type of Cars.** Must closed cars be used in winter, and must they be heated?

(16) Is the voltage and kind of **Current** to be used restricted by present plants? Describe completely.

(17) If **Estimated Cost** is to include the following, describe fully.—Bridges, viaducts, cuts, fills, retaining walls, fences, waiting rooms, platforms, etc.

(18) Submit copies of all municipal or government **Regulations** on the subject of electric street railways.

(19) **Interurban Tracks.**—If estimated cost of these is desired, submit data as for steam railroad locations (p. 41).

II. Location and Construction of the Generating Station

A. Steam Electric Power Plants

Several sites will probably be under consideration, within the city, in the suburbs, or in an isolated location. Mark on the map the proposed sites, number them, and for each one report on the following considerations.

(20) Municipal or other **Ordinances** (either existing or probable) concerning smoke, noise and ash nuisances, that may cause trouble in operation; concerning character and appearance of building that may be erected in certain localities; etc.

(21) Location with reference to **Center of Distribution** (important for direct generation of low-voltage circuits, not so much so for high-tension, step-down systems.)

(22) **Coal Supply and Ash Disposal.**—Relative costs of coal as delivered on a siding, in barges alongside station, etc.
Method of disposing of ashes.

(23) **Water Supply** for boiler-feed and for condensing purposes. For the former, state amount available and submit analysis or sample. For the latter, state amount available and quality.
If quantity is limited, consider possibility of a cooling tower; also note that steam turbines require far more cond. water than reciprocating engines.

(24) For all sites under discussion, state possibility of acquiring property for **Enlargement** of plant.

(25) For all sites under consideration, ascertain probable **Cost of Land,** obtaining options if necessary.

(26) **Character of Foundation Soil.**—Option on property should contain clause allowing borings, etc., to ascertain this. Make a thorough examination and report, sinking test holes or pits every 50 ft or so apart, so that there may be no question as to conditions to be encountered. (See pp 2 and 18)

(27) **Coal Storage.**—Ascertain and describe possible sites for storage of a large amount of coal to tide over shortage due to strikes, etc. Discuss style of coal-handling plant probably best suited to each; and method of getting coal to site and from site to power house.

(28) **Labor Supply.**—Desirability of site from point of view of operators: possibility of attractive local housing, or of good transportation from such.

(29) **Factors Influencing Cost of Construction.**—Possibility of obtaining, and cost of, local stone, sand, brick, cement, piles, etc., that may be used in construction.
Method and probable cost of transporting building material and machinery to site.

B. Hydro-electric Power Plants

In the U. S., the maps, stream gaugings, etc., of the U. S. Geological Survey contain very valuable data and are available for many areas. In other countries, however, it may be necessary to make more or less complete surveys to obtain much of the data called for below.

In connection with small hydro-electric developments it should be remembered that quite small streams may often be utilized by building a storage reservoir large enough to impound the water required for the few hours of the day when the plant will be in operation, say during the lighting hours of the evening.

(30) Submit a **Map** of a suitable scale of the entire water-shed, topographical if possible. This map should have marked on it the low-water quantities of stream flows, possible dam sites, power-house sites and flumes, etc., all numbered so that reference may be made to them in the report.

(31) Obtain **Drainage Areas** of the various watersheds considered, marking same on map.

(32) Obtain, for as long a period back as possible, records of the weekly or monthly **Rainfall** of the district. If the watershed is extensive and records are only available for a portion of it, obtain local information concerning relative intensity of rainfall in other parts of the district.

(33) Submit information concerning the **Geology** of the district, with special reference to the capacity of the soil to absorb rainfall; and the existence of strata, faults, caves, etc., that produce and extend the flow of springs.

(34) Obtain information concerning the extent and frequency of **Droughts and Freshets,** especially with reference to the longest period of the low water conditions. Effect of **Snow** on these conditions.

(35) Character of the **Vegetable Growth** covering the area, both timber and underbrush, as affecting the quickness of run-off. Submit typical photographs. Possibility of future timber cutting or fires.

(36) Describe the **Evaporation** condition of the district, both as it will effect the run-off and the loss from dams.

(37) Make **Stream Gaugings** of the main branch, and of tributaries if necessary, **following the directions given on p. 25;** a single gauging is worthless or worse. For methods see pp. 25–29.

(38) For each dam site proposed, submit a topographical **Map** which will show, also, the submerged area to such a scale as will enable reliable calculations of capacity to be made.
Note.—Dams are built (1) to obtain *head,* such as those across a slow-moving river of which only a portion of the water is utilized, and (2) to ensure *storage* of water to last over dry spells.

(39) Sink **Test Pits** and make borings at frequent intervals over the site of the dam, and make suitable record of results; see p. 2.

(40) Examine the **Site of the Reservoir** with a view to its probable capacity to retain water under the new head. Report on character and amount of **Drift** material, logs, leaves, ice, etc., that may be expected.

(41) Report on the amount of **Silt** that may be encountered, both at average flow and flood, with reference to the filling up of the reservoir.

(42) Must **Fish Ladders** be installed? Submit government regulations on conditions to be met.

(43) **Power House.**—Locate possible sites on map; examine foundation material.

(44) **Head.**—Run a line of levels along the stream at all points where a dam and its power house is proposed, so that accurate calculations may be made as to the head available for different locations.

(45) **Auxiliary Power.**—This may be used at periods of low water or at periods of customer's peak, and may be obtained from steam, water or gas. Report on probable most satisfactory power available, considering cost of fuel, labor, etc.

(46) **Materials.**—Report on material available locally for dam, flume, and power-house construction; stone, sand, brick, timber, cement, etc.

(47) **Transportation.**—Report on present means of transportation and probable roads, etc., to be built.

(48) Report on **Ownership** of all properties and clearness of title to same, and on **Water Rights**; consult a lawyer if in doubt.

III. Transmission Lines

(49) Submit a topographical **Map** of the district through which the line will be run, and indicate on it the areas of forest, scrub, rock, cultivation, marsh, etc.

(50) State what terms can be obtained for a **Right of Way,** assuming a width of from 50 to 100 ft. with right to remove adjacent threatening timber.

(51) Will the line be subject to forest **Fires?**

(52) State any preference or consideration affecting the kind of **Pole** to be used, wood, steel or concrete. If the former is to be used, is it possible to obtain poles locally? State sizes that can be procured and cost of same.

(53) **Transportation.** See (55)

(54) **Meteorological.** See (58)

IV. General Considerations.

(55) **Transportation.**—Capacity of lighters and of derricks on wharf at point of debarkation. Capacity of railroad from port to site of works, clearance diagram, heaviest pieces that can be handled. If material will be transported over bad roads or by mule-back, describe limitations.

(56) If quotation is to be for material delivered on site, submit information concerning **Customs Duties,** lighterage, port charges, etc.

(57) Report on **Labor** that can be obtained locally; supply and capacity of artificers, laborers and operators; submit table of wages and efficiencies as compared with similar workmen in the U. S.

(58) **Meterological.** State general climatic conditions of the locality; frequency and severity of snow and wind storms and of **lightning;** consider in special reference to effects on high-tension transmission lines, lightning arresters, etc.; presence of dust or smoke that would produce similar deleterious effects.

RAILROAD PROMOTION; SCHEDULE OF INFORMATION TO BE SUBMITTED TO CAPITALISTS AND CONTRACTORS[1]

The schedule given below outlines a large amount of detail work, more than is necessary for preliminary estimates and financial considerations. The completeness of information to be submitted will de-

[1] Adapted from Ewing Matheson's "Aid Book to Engineering Enterprise," E. & F. Spon, London.

pend on so many and varied conditions, that it is impractical to indicate how much may be omitted. In general, however, it may be stated that the more complete the information submitted, the greater will be the consideration afforded and the closer the price.

(1) Supply a general **Map** of the country, showing existing railways, roads, canals, rivers, mountain ranges, etc., and showing the route proposed for the new line.

(2) State the supposed **Utility** of the new railway, and the reasons generally that have been suggested for its construction.

(3) The **Concession** or Legal Powers under which the line is to be built; state the general nature of the concession obtained or desired.

(4) Submit a **Plan** of the line itself, on a larger scale than the general map, showing the topography, the rivers and roads to be crossed, the towns and villages to be passed, and the limits of deviation which the concession allows.

(5) Indicate on map and submit verified data as to the **Population** of the various places on and adjacent to the railway, and the kind of trade or occupation in which the inhabitants are engaged. Also indicate location and kind of mills and factories.

(6) Estimated **Traffic.**—State nature and amount anticipated and calculations of revenue based thereon. Also describe existing methods of transportation, amount and charges. Submit contract or agreements made with shippers for guaranteed business dependent upon completion of railways by a specified date, etc.

(7) **Gauge.**—State whether standard or a narrow gauge is proposed. Some items influencing the choice are: cost of works and rolling-stock, nature of traffic, curvature necessitated or allowed, probable future traffic, and (most influential of all) the gauge of neighboring railways with which connection is proposed or is possible in the future.

(8) State maximum **Grade** and **Curvature** proposed, and whether the former is to be compensated for curvature.

(9) **Class of Construction** proposed for track, bridges, buildings, locomotives and rolling-stock.

Track.—Weight of rail; style of fastenings; cross-ties; ballast; switches; signals; etc. (See also p. 188.)

Bridges.—Loading proposed; material; substructure; overhead bridges, etc. (See also p. 30.)

Buildings.—Class of construction for terminal and way stations; description of any extensive buildings proposed; round-houses; repair shops; etc.

Locomotives.—Give number and classes of locomotives estimated as required. (See also p. 167.)

Rolling Stock.—State proposed number and class of passenger coaches; and of freight cars. (See p. 169.)

(10) Submit a **Topographical Plan** and a **Profile** of the line on a convenient scale, showing proposed gradients, cuts, fills, tunnels, bridges, etc. Also indicate, on the same sheet, any alternate routes possible.

Note.—The degree of completeness with which such a plan is made should be governed by the probability of completion and the finances available.

(11) **Nature of Soil.**—The class of earth or rock at each cut or tunnel should be indicated, as accurately as obtainable, on the profile. The geological indications, both periodic and economic, should be observed and noted as closely as possible. At proposed tunnels, note the possibility of intermediate shafts being sunk, and the probability of water being encountered, as influenced by

the strata above or below: effect of the above on the time necessary for completion.

(12) In the case of **Large or Important Bridges** special information should be afforded for estimating approximately the cost. (See p. 30.)

(13) Local **Materials of Construction.**—Describe as completely as necessary, giving the character, suitability, estimated amount, location, accessibility and cost; the occurrence of the timber, brick, clay, stone, sand, ballast, lime, etc., to be obtained in the neighborhood of the railroad.

(14) **Fuel and Water.**—State whether wood, coal, or oil is proposed for use as fuel, giving availability and costs. Inquire particularly as to the water available for locomotives along the proposed location, submitting analyses in the case of bad waters requiring special treatment before use.

(15) **Imposts and Transportation.**—State what import duties, landing charges, taxes, etc., have to be paid, so that estimates may be made. Also describe facilities for landing or handling material at port, and for transporting to the working line. Give the character of the roads, beasts of burden, etc., available for the whole line, so that allowance may be made for hauling material ahead.

(16) **Climate,** etc.—State the effect of climate on the health, hours of labor, etc., of both imported workmen and natives. Also describe meterological conditions; rainfall, snowfall, averages and extremes of temperature, hurricanes, earthquakes, floods, etc., that may affect the construction or operation of the line. State whether insects or wild beasts are liable to destroy material or interfere with construction or traffic.

(17) **Workmen.**—Availability of native population for skilled and unskilled positions, both in construction and operation; possibility of importing laborers; possibility of having portions of the work done by local sub-contractors. Schedule of wages paid and perçentage of efficiency (in each case) as compared to foreign workmen. Facilities for housing and boarding imported workmen.

(18) **Right of Way.**—Conditions under which the land for track and buildings is to be acquired; probable prices to be paid; time required to obtain possession; cost and time of condemnation proceedings; attitude of landowners.

(19) **Conditions** imposed by the authorities as to kind of works, width of gauge, gradients, engines, etc., etc., *i.e.,* **Regulations** of the Public Works Dept. or equivalent.

(20) **Interchange of Traffic** with adjoining railways. Terms should be very carefully arranged beforehand, etc., so as to avoid possible onerous conditions after project is started. This applied also to transportation of construction material while building.

(21) **Terms of Payment** to Contractors.—The proposed methods of payment, whether in money, part money and part scrip, retention of percentage, etc., should be stated.

Water-works; Information to be Submitted for Obtaining Design and Estimate[1]

(1) A **Map** of the town and adjoining country, showing the position of the wells, springs, rivers, or lakes, from which water may be obtained. If possible this map should show the topography of the area; but if such a map is not obtainable, the heights of prominent elevations, natural basins, and other sites suitable for reservoirs or filter beds may be indicated by figures giving their elevations with reference to some fixed datum in the town.

[1] Adapted from Ewing Matheson's "Aid Book to Engineering Enterprise," E. & F. Spon, London.

(2) **Geology.**—Both the superficial and the regional geology of the district should be examined and indicated as accurately as possible. At places where works are proposed, test holes or borings should be made (see p. 2), and the results recorded.

(3) **Sources of Supply.**—Gauge existing streams or indicate their catchment area. Obtain data as to quantity of flood-waters, duration of flow, and effect of floods on quality of water.

Describe the dry seasons, if any, which produce a scarcity of water; so that, if necessary, the scheme may include provision for water storage.

Describe existing wells, the quantity of water than can be obtained from them, their water-levels, and liability to contamination from surface drainage or from mining operations, etc.

(4) **Samples.**—Obtain samples for analysis of the different waters proposed in the manner described on p.306. Label clearly and record.

(5) **Water Rights.**—Submit information as to the right to take water from sources proposed, whether arrangements can be made with riparian owners below, or whether legislation may be necessary. If mills, etc., are situated down-stream, data should be submitted as to the amount of power taken by them.

(6) **Present Supply.** — Give a description of the existing water supply, its quantity, quality and cost to the inhabitants.

(7) **Power.**—Describe power available for pumps, whether hydraulic, electric, oil, steam, etc., giving costs of each.

(8) Submit a **Plan** of the town showing streets, proposed location of main and branch pipe lines, location of large water users, etc. The plan should be topographical, or should have elevations indicated in some other convenient way.

(9) **Imposts and Transportation.**—Give the information outlined by Sec. (11), p. 49.

(10) **Workmen.**—Follow Sec. (12), p. 49.

(11) **Local Materials** of Construction.—Give information as to the kind of gravel or sand obtainable as suited for filter beds; of sand and rock for mortar, cement, or concrete; clay for puddling; lime, cement, bricks, stone, timber, etc., for building purposes; and iron pipes and fittings.

(12) **Climate.**—Describe the climate as per outline on p. 43, Sec. (16); and also give the rainfall for each month for as long a series of years as possible, and how it has been ascertained; the evaporation, and how it has been ascertained; the degrees and continuation of frost, and the depth to which it enters the ground; the thickness of ice on the rivers, and how often it occurs; the temperature, maximum and minimum, of the water to be used.

(13) If Pumping Stations are proposed describe the **Foundation Material,** and state whether condensing water is obtainable.

(14) **Pipe-line Excavation.**—Describe the soil and subsoil in which trenches will have to be cut. Existing sewers, gas-pipes, etc., should be located on the plan.

(15) **Land.**—Follow Sec. (13), p. 48.

(16) Give the **Population** of the town and district to be served with water, the rate of increase during preceding years, and the probability for the future.

(17) State the number of **Houses** and tenements, the rentals per annum, divided into classes, advancing by steps of about $50. State the average height of the houses and the maximum height.

(18) Give information as to the **Occupations** and wealth of the inhabitants as an aid to estimating the amount of water they will use and their ability to pay for it. For example, state whether baths are usual in the houses, whether linen is washed at home, whether houses and streets are drained and whether any complete system of drainage is established in the town, or is in contemplation.

(19) Submit as much information as possible as to any **previous systems** of water supply that may have been prepared.

Drainage and Sewerage Disposal System for a Town

The following enumerations outline the data that should be collected by an engineer on the ground, for use in obtaining a report and estimate on a proposed system of sewerage and disposal works for a small town. The data may be obtained by a local engineer (not necessarily an expert on sanitary work) for the use of a specialist, or by a representative from the consulting engineer's office.

(1) A **map of the district,** on a scale of (say) 6 in. to the mile, with contour lines, of sufficient extent to embrace the whole area to be drained and any possible location of disposal works, and to indicate the natural drainage of the district.

(2) A **map** to a larger scale (up to 5 ft. to the mile) **of the immediate area** to be drained. If a contour map cannot be obtained elevations at different parts of the town should be given, together with sections at suitable places so as to show the general contour.

(3) **Photographs** of typical parts of the community; these are useful in supplying a more intimate idea of the local conditions.

(4) A general **physiographical description** of the district, stating whether it is rugged or flat, height above sea-level, etc.

(5) A description of the **geological features**; stating the formation, dip of the strata (submit approximate sections if possible) and whether there are any faults; whether any mines or salt measures have been, or are being worked, and their tendency to cause settlements.

(6) Ascertain and submit data as to the **rainfall.** This should include the fall by months for (say) 10 years back, or the yearly fall for 20 years or more; and records of the heaviest falls per hour and day, and the frequency of their occurrence.

(7) Give the **present population** of the district and of the various portions of the district, making a special note of any institutions with a proportionately large population such as asylums, prisons, colleges, etc. Indicate boundaries and locations clearly on the map.

(8) Indicate on the map the probable **increase in built-up area,** and state the rate of growth and character of population that may be expected.

(9) Describe the **water supply,** its source, distribution, whether all houses are supplied, consumption per day per capita, quantity used by the large institutions above referred to.

(10) A description of **existing methods** of house drainage with sketches of typical sewage arrangements. Also furnish a description of any trade refuse that may have to be disposed of.

(11) A description of **existing sewers,** their construction, fall and utility. Also, whether these sewers receive surface waters and their utility for this service; whether the town is paved, and how much of it; other road surfaces.

(12) If the **sea** is available for disposal, indicate on map points suitable for discharge of sewers, describing nature of the shore and existence of mud banks, etc., likely to obstruct the flow. Indicate the levels of the average tides and of extraordinary tides. Ascertain (by means of floats) the direction in which sewage will be carried under different conditions of currents and winds.

(13) If a **river** is available for disposal, submit data as to quantity of flow at high, low and extraordinary levels (see p. 25); velocity of current at the town and for some miles below; and state whether, and at what places, water is taken for drinking purposes. Describe the material of the banks and submit cross-sections to show slopes.

(14) If sewage **disposal on land** is contemplated, ascertain the drainage capabilities of the soil; whether the land is waste or cultivated; crops that can be raised; their probable value; markets; increase in value of the land; dwellings in the vicinity; probable opposition to works.

(15) **Meterological.**—In addition to the information in (6), state the general character of the climate, giving extremes of temperature, etc.

(16) **Regulations.**—Submit information as to state or municipal regulations to be complied with; procedure for obtaining franchise, etc.; whether by-laws will be granted to enforce proposed sanitary methods, and whether the enforcement of these laws can be relied on; origin of the proposed improvement.

(17) Give the probable **values** at which land required for pumping plants, filter beds, etc., may be acquired and the tenure under which same is held.

(18) Submit data as to the labor and **building material** available; cost of coal or other **fuel** (if pumping-stations, etc., are probable); **transportation** facilities.

(19) **Financial.**—Outline the scheme by which it is proposed to pay for the installation.

References

Matheson's "Aid Book."
Noel Taylor's "Main Drainage of Towns."

Irrigation Works: Information to be Submitted for Obtaining Design and Estimate[1]

"The information that serves as the basis for an irrigation project is of two kinds, the one comprising the local condition from an engineering and an agricultural point of view; the other being of a financial and economic nature. Details of the concessions or privileges that will be granted, of the sources from which the works will be paid for, and other information as to the nature of the engagements contemplated, are indispensable portions of works of irrigation.

"The following list enumerates those particulars to which, some or all of them, according to the nature of the case—an irrigation engineer on the spot would direct his attention. In countries where there do not happen to be any competent resident engineers, the best method is to collect so much of the information enumerated below as is within the means at command, and to place it before a competent engineer in England, who can advise on the *prima facie* conditions of the case. Some of the particulars enumerated demand the services of a surveyor or engineer accustomed to measuring land and taking levels; others demand geological and meteorological knowledge; while some of the par-

[1] Taken *in toto* from Ewing Matheson's "Aid Book to Engineering Enterprise," E. & F. Spon, London.

ticulars are merely matters of fact which can be ascertained by any person of intelligence in the locality."

(1) A **Plan** showing the area to be operated on, with the names of the owners and occupiers marked upon it, and a sufficient number of levels referring to a datum.

(2) A series of **Sections** on all the more important lines, such as the course of streams or rivers, the water-sheds, the approximate courses of proposed canal and distributaries; also a series of sections over the sites for storage, if these enter into the design.

(3) General information as to the natural and **Physical features** of the locality.

(4) A full and detailed account of any **Existing irrigation** works in the neighborhood, even though they be only on a very small scale; with remarks on the difference of conditions between them and the proposed works; and accounts of any neighboring navigable canals.

(5) Data for calculating the amount of natural **Water-supply** available at various points in different seasons: if the source of supply be by one or more rivers, then soundings, showing the water-level at various seasons in flood and in drought should be given; a demarcation of the limits of area submerged at various times; the points at which over-flows take place; the periods and deviations of floods and droughts; the tendency of the river to deposit silt and the quality and amount of the latter under different conditions and velocities. Should it be intended to take the supply from wells, full particulars of those already existing should be given, as well as regarding the probable depth and copiousness of supply from the proposed new wells, and the geological strata that will most probably be met with in sinking them. Should the storage and collection of surface water, or the interception of streams by dams, be depended on as a source of supply, full information becomes necessary regarding both the geological and meteorological conditions of the catchment area; this should include all available data of rainfall, evaporation, humidity and absorption. The seasonable occurrence of the rainfall is even more important than a copious supply. In the Orissa famine year (1866) the rainfall was considerably above the average, but it was ill-timed. A description of the superincumbent geological strata, and an account of the mode in which every part of the area is occupied or used, should be furnished.

(6) Existing examples of the amount of **Water required** for watering both in the gross at various seasons over the irrigable area and in detail per acre on various soils; and the probable effect on the crops of increasing the supply.

(7) Full information about the **Irrigable Area** itself, its various soils, the crops that are and may be grown on it, and anywhere near it, their rotation and probable yield in favorable, average and unfavorable seasons, and their market value; the systems of tillage in vogue, and the proposed modifications; the trees, shrubs and plants that are most common, and those growing on the banks of the rivers and near marshes, and the condition of such vegetation, whether thriving or otherwise; the effect on the soil of periodic watering and long-stagnant water; the climate and meteorological conditions of the area to be irrigated.

(8) The Soil in which the proposed works will be carried out; the stone, lime, clay, brick-earth, and timber available, and their cost; the expenses of **Transport,** and the kind and cost of **Labor** that can be obtained.

(9) The kind and cost of **Fuel** which is obtainable for pumping engines; the local opportunities or facilities for pumps to be worked by wind or water power.

(10) A careful estimate of the value of the average **Yields per acre** of non-irrigated

land in the neighborhood, and, secondly, that of the average yield that irrigated land will produce under the proposed system of rotation, after making allowance for unfavorable years and agricultural contingencies. The number of the population, their habits and capabilities of using irrigated land.

(11) The **Communications**—roads, railways, and canals—by which the produce of the land can be transported; the proximity to markets, and rates of freight by various routes.

(12) If sewage-irrigation is contemplated, the kind, richness, and amount of the **Sewage,** the source of supply, and the terms on which it is to be obtained.

(13) The **Tenure** on which the land is held; the compensation to be paid for the extinction or lease of proprietary rights; the amount of capital which will be contributed by the landowners, tillers, or by local capitalists; the facilities, assistance, contributions, or guarantees which will be granted by the Government.

Pier or Wharf; Information to be Submitted for Obtaining Design and Estimate[1]

"To enable an engineer to make a suitable design for a landing-pier, and a contractor to estimate the cost, it is absolutely necessary that sufficient information of the kind enumerated in the following list be furnished. The expense incurred in obtaining these preliminary particulars will be amply repaid, for unless based on actual facts, any so-called estimate of cost is fallacious" (E. M.).

(1) Submit a **Plan** of the site drawn accurately to scale, showing the coast-line and the position proposed for the wharf. Also show a **Section** along the line of the wharf, giving the levels of the road, quay, or other approaches, and the slope of the sea-bed, with the soundings and tide levels of the water at all seasons.

(2) **Foundations.**—Make borings at intervals on the site of the wharf in order to obtain information as to the character of the sea-bed. (For a method of making such borings see p. 11). The location of these borings should be indicated and numbered on the plan, and the character of the material encountered indicated by section sketches. The borings should be carried down far enough to indicate practical bearing material.

(3) **Service.**—State for what purpose the wharf is to be used; whether for landing passengers only, landing freight, storing, loading coal, etc., etc. State capacities, etc., to be handled or stored.

(4) **Vessels.**—Describe the class of vessels that will lay alongside the wharf, stating their gross tonnage, length, draft, free-board, etc. It is always advisable to send a diagram of the vessel or vessels, showing a longitudinal section, plan and section amidships, and it is essential in the case of vessels whose cargoes will be handled by cranes, staithes, etc.

(5) **Meteorological.**—Describe and give direction of currents or prevailing winds that may determine the position for vessels to lay alongside. The liability, if any, to storms; their force and effect; and the seasons at which they generally occur.

(6) **Superstructure.**—State whether any shed or other building is to be placed on the wharf, and describe fully the purpose for which it is to be used. If possible,

[1] Adapted from Ewing Matheson's "Aid Book to Engineering Enterprise," E. & F. Spon, London.

submit a plan and elevations showing the buildings and also the cranes, tracks, etc., mentioned below.

(7) **Storage.**—If goods are to lie on the wharf, state, either the weight per square foot to be carried, or, if this is unknown, describe the kind of goods and give the height to which they will be piled.

(8) **Cranes.**—State whether these are desired, to be fixed or movable, maximum and average loads to be raised, power to be used.
If fixed, indicate where they are to be placed. If movable, give the gauge of track rails, and indicate the portion of the wharf to be covered and structures to be cleared in moving.

(9) **Tracks, Roadways, etc.**—If railroad tracks are to be laid, state the number and gauge, and weight of locomotives coming on the wharf; and indicate by sketch any cross-overs, etc., proposed.
If carts or wagons are to come on the wharf, give their maximum weights and clearance dimensions. Indicate the position of stairways, gangways, etc., desired.

(10) **Materials of Construction.**—State any preference desired as to the construction of the wharf, superstructure, cranes, etc. In case local material is available, such as wooden piles, lumber, sand and stone for concrete, cement, etc., give costs of same at site of wharf and state their quality.

(11) **Imposts and Transportation.**—State what import duties, landing charges, taxes, etc., have to be paid. Also describe facilities for landing and handling material at port and for transporting to site

(12) **Workmen.**—Availability of native labor for skilled or unskilled labor; possibility of having portions of the work done by local sub-contractors Schedule of wages paid and percentage of efficiency (in each case) as compared to foreign workmen; facilities for housing and boarding imported workmen.

(13) **Government Regulations.**—State whether regulations of the War Dept , Public Works Dept., etc., have to be complied with, and furnish copy of same if foreign.

An Aerial Cableway: Information to be Submitted for Obtaining Design and Estimate

The design of aerial cableways is undertaken almost invariably by the engineers of the firms supplying the wire rope and other items entering into their construction. The work is of a very special nature, and these firms, through long experience, are best fitted to advise concerning the type of cableway best adapted to the conditions presented; for the possible combinations of rope-arrangement, type of supports and of carriers, etc., etc., are practically infinite. It is important, therefore, in order to secure the best final results as influenced by considerations of first cost, cost of operation, and cost of maintenance, depreciation and renewal, to collect and submit to the bidders all matters that can possibly affect these factors. The following list of items outlines the data which should be considered and forwarded for presentation to the contractors.

(1) State the **general purpose** of the system.

(2) Describe in detail the **material** to be conveyed, giving average and maximum

size of lumps, weight per cubic foot, whether dry or wet, whether of corrosive quality, etc., etc.

In cases of boxes or barrels, or of bulky material such as lumber, give dimensions and weights of average and maximum pieces.

(3) State **maximum amount** of material that will have to be conveyed **in any one hour,** and **total amount in 12 or 24 hours.** (Do not use the word "day.")

(4) State amount to be handled **per year.**

(5) State **total amount of material** to be handled by the installation, if this is a definite quantity. (Note.—These two items are necessary for the purpose of gauging the life of the cableway and the class of machinery which it will be profitable to install.)

(6) Submit a **profile,** accurately to scale, of the proposed route or routes; noting thereon, particularly, the probable greatest spans.

Note that **angles or turns** can be negotiated if necessary, but the construction of these angle stations is liable to be expensive. If they are inevitable, however, submit also a plan of the route with the angles correctly marked.

(7) In case **power** will have to be used for operation, *i.e.*, when the loads on the descending grades are insufficient to insure gravity operation, state whether steam, electricity, gasoline, water-power, etc., is to be used, giving requisite data concerning the class of power available. (See p. 39 (16.)

(8) **Loading Station.**—Describe method by which material will be delivered to the loading station (*i.e* , by carts, bottom-dump wagons, etc.) and at what elevation, so that a design for a loading station may be proposed; also show on profile.

How frequently will wagons, etc., deliver? What capacity in loading-bins should be provided?

Is it desired to load the material by hand, or are automatic loading devices to be installed so as to save labor costs?

(9) **Unloading Station.**—Describe method by which material will be handled after delivery to unloading station, *i e* , whether it is to be discharged into a bin for loading cars, etc.

What capacity in storage-bins is to be provided? At what elevation (above water-line or ground-line) is chute of bin to deliver? Indicate elevations on profile.

Is it desired to have buckets released from cable and discharged by completely automatic devices, or is labor sufficiently low-priced to render hand operation preferable?

(10) Are any **intermediate loading** or unloading **stations** desired at any point in the line?

(11) Is it desired to **weigh each load?** If so, at what point should scale be located? Or will a counter (to record number of buckets) be sufficient?

(12) **Of what material is it proposed** to construct the framework of, (1) the loading station, (2) the unloading station, (3) the angle stations, and (4) the line towers; wood or steel? In case of former, describe the available material sufficiently so that drawings and bills of lumber may be made to suit.

(13) Mark on the profile the **elevations** of any structure over which cableway is to pass, so that clearances may be observed.

(14) Will it be necessary to provide **nets or platforms** over buildings, R. R. tracks, highways, etc., above which the cableway will pass? If so, and if the material is to be supplied by this contractor, give detailed information (plan and section) of place to be protected.

(15) **Material to be Supplied.**—Enumerate the items in the following list which are

to be supplied by the cableway contractor, also those which are *not* to be supplied.

(a) Items usually furnished by cableway contractor—The special material of the plant including cables, supporting irons or sheaves, guard irons and sheaves, end-sheaves, all special iron work used for construction of end and angle stations, all special material for tension stations, the gearing and other mechanism at the driving station up to the point of connection to the motive power, the buckets or other carriers, automatic loading device, scales, counters, automatic discharger; and all drawings, bills of material, etc., necessary for the construction of the (wood or steel) supports, end stations, etc.; and information concerning erection of the cableway and arrangement of motive-power.

(b) Items usually furnished by others from drawings or lists supplied by cableway contractor—Structural steel for towers; end, angle and intermediate stations; complete loading and unloading buildings including bins; supports for safety platforms or nets; wood framing for the same purposes, and all plain bolts, spikes, etc., for their construction; the motive power, boiler and engine, gasoline engine, electric motor, water turbine, etc.

(16) **Meteorological.**—Describe severity of high winds or snow-storms which may affect operation of cableway.

(17) **Transportation.**—State whether any parts of the machinery will have to be transported by mule-back or by other carriage that will restrict weight of individual packages. (See p. 373)

(18) In calling for **quotations,** follow outline on p. 213.

Cane-sugar Factory: Information Required for Submitting Design and Estimate

Items number (1) to (28) embrace the information necessary for designing a factory and submitting a price on the machinery and building material f.a.s. at a shipping port; the remainder of the items indicate the additional information necessary in case a bid or an estimate is to be given for the factory erected and in running order.

The outline is *suggestive* for similar schedules for industrial plants.

(1) In what **country** is the factory to be located? Also state **province,** and nearest **town** if possible.

(2) **How many tons** (of 2,000 lb) **of cane** will be ground per day?

(3) How many **hours per day** will the mill be grinding?

(4) What is the percent **Fibre** in the cane?

(5) What is the percent **"Sucrose"** in the cane?

(6) What is the percent **Purity** of the juice?

(7) Is there a **supply of good water** near the site of the proposed factory?

(8) How **far is the water** from the factory?

(9) What **quantity** is available per hour in U. S. gallons?

(10) What is the average **temperature** of the water?

(11) Is the **source of the water** above or below the ground floor line of the factory, and how far?

(12) Will the cane be brought to the factory in **railway cars;** and if so, what is the size of the cars and the **gauge of the track?**

(13) Will an automatic **cane unloader** be required to unload the cane from the cars?

(14) Will an **electric lighting plant** be required?

(15) If so, will there be any **lights** required in addition to what are necessary for lighting the factory and yard, and about how many lights?

(16) Will electric motors be installed to drive the **auxiliary machinery** in factory, or are steam engines preferred?

(17) Is it intended to make a granulated white, or a semi-refined washed **sugar to be sold in the market,** or 96° centrifugal to be sold to **refinery?**

(18) Give size of **sugar storage room** required.

(19) Is a **bagged sugar conveyor** desired for the sugar storage room?

(20) What will be the dimensions and weight of the **filled bags?** Will they be paper-lined?

(21) What will be done with the refuse **molasses,** and to about what **purity** will it require to be reduced?

(22) How long does the **grinding season** last?

(23) At what **date** must this factory be ready for grinding cane?

(24) Is a fully equipped **machine shop** required?

(25) Are **molasses storage tanks** required and for about what capacity (in U. S. gallons)?

(26) If the water-supply is scanty, so that a **cooling-tower** may be required; describe the force, constancy, etc., of the **winds** that may be expected and state (in general terms) the relative humidity of the atmosphere.

(27) If a cooling tower will probably be required (it should preferably be placed on a slight elevation), state **how far from the factory site** it will be located, so that an estimate may be made of the amount of piping required.

(28) What **type of building construction** is desired? If of corrugated steel on a steel frame: Are the floors to be of wood, concrete or steel plate; are the windows to be of glass, steel shutters, or gratings; is the usual finish, gutters, etc., to be supplied, or is the building to be as plain as possible?

Additional information required if bid or estimate is required on the factory erected and in running order.

(29) **Freight charges;** will these be paid by owners or by contractor? If by the latter, give all information as to landing charges, facilities at wharf and on railroad for handling heavy machinery, a full schedule of freight charges, maximum capacities of cars and clearance limits on the railroad, facilities for unloading, distance from railroad to site of factory and means of transporting material this distance with costs.

(30) **Customs Duties;** will these be paid by owners or by contractor?

(31) State possibility of obtaining, and cost of site of **red brick, lime, sand and stone** for concrete, sand for mortar, lumber, cement, fire-brick, etc.

(32) Is **native labor** available for skilled and unskilled work? State the wages and relative efficiencies of each class as compared to imported labor. State the possibilities of obtaining work done by sub-contract, with costs.

(33) What is the character of the **foundation material** on the site of the factory? If possible, state its safe load-bearing value. (See p. 18.)

(34) Will **factory supplies** for the test-run period be paid for by the owners or by the contractor?

(35) State any government **regulations** as to buildings, labor, licences, etc.

Choice of a Factory Site; Points to be Considered

(1) Location with regard to **raw material;** total resultant freight charges on same to site to be a minimum: locate so as to take best advantage of gravity operations.

(2) Location with regard to **transportation:** advantages of water transportation; advantages of water transportation for bulky or heavy material; advantages of a R. R. centre or junction; possibility of convenient R. R. spur; convenient dock facilities.

(3) **Labor.**—Advantages of city for a business with a fluctuating labor demand; advantages of country for contented and cheaper help in a stable industry; advantages of suburban location as a compromise; suitable housing or housing site; living expenses; prevailing rate of wages; quantity of labor available, quality and probable fields of supply.

(4) **Value of Property.**—First cost; appreciation in value; tax-rate.

(5) **Special considerations** peculiar to the industry; see other schedules.

(6) **Fuel.**—Ascertain quality available; get samples for analysis (see p. 296); price f.o.b.; quantity available; whether special terms can be arranged; standing of mining or distributing company, and possibility of acquiring control of same.

(7) **Water for Condensing Purposes.**—Source; salt or fresh; mechanical or chemical impurities; if foul, and liable to attack metal or packing in jet or surface condensers, obtain sample for analysis, and if possible ascertain effect on apparatus in neighboring plants; temperature (important); quantity; variation of flow; level above or below (mill floor) datum; variation of level.

(8) **Water for Mill Use.**—Source; ascertain temperature, quantity, level, variation in quantity and level, quality (obtain sample for analysis); special quality desired or not desired for certain trades.

(9) **Drainage Conditions.**—Show direction of probable sewer on map (13); give available fall; final disposition (cess-pool, stream, river, etc.); special considerations of water-polluting trades.

(10) **Atmospheric Conditions.**—Direction of prevailing wind (with reference to location of ventilators, disposition of fumes and smoke, etc); severity, frequency, direction and characteristics of average and of greatest storms, maximum wind-velocity in miles-per-hour (important); yearly rainfall, its distribution by months, maximum fall, reliability, etc. (get data from Weather Bureau); yearly snowfall, its distribution by months, maximum depth, etc. (from W. B.); get data on sunlight, cloudiness, etc., if of effect upon the industry.

(11) **Earthquakes Inundations, Etc.**—Liability, recurrence and severity.

(12) **Foundations.**—Safe bearing power of foundation soil at requisite depth at various positions on site (see p. 18).

(13) **Topographical Map.**—This is always desirable and frequently imperative; much of the information noted above may be conveniently shown on this map; for large areas (sugar-plantations, etc.) should include the whole and contiguous area, with factory site in greater detail.

(14) **Building Operations.**—Quality and cost of available building material, lumber, sand, stone, brick, etc.; quality and rate of wages of available labor, skilled and unskilled; provision for housing builders, with costs; transportation of building material and machinery to site, capacities of cranes, wharves, rolling- stock, tunnels, bridges, unloading devices, highways, etc., freight rates (special arrangements); customs duties on all material (straighten out obscurities); building laws; boiler rules; employers' liability laws.

CHAPTER II

DESIGNING AND DRAFTING SYSTEMS

Introduction

In this chapter is presented in tabulated form the routine of the more common cases of engineering design and drafting. Many important branches of engineering, however, have not been referred to at all for reasons explained in the preface to this volume, but it is believed that sufficient examples have been given to point the way to the compilation of similar "reminders" on other work. The chapter is written more particularly from the standpoint of the man on the board; the idea being that the reminders be consulted either before or after the completion of a design to make sure that there have been no serious errors, either of commission or omission. It is the result of an idea of the author's when he first entered a drawing office, an idea hazy at the time but gradually crystallized, that there ought to be some system in use for preventing, to a certain extent at least, his frequent mistakes and omissions at that period of his apprenticeship.

It is realized, of course, that no system can take the place of experience, but there can be little objection to the use of system to aid and force experience, and this is the idea intended to be conveyed by the items of this book in general and this chapter in particular. Most engineers for their private use, and some firms for circulation in their own office, compile "reminders" similar to those given below, but the distribution of these is limited; and to the young engineer therefore, and also to those engineers who have not the systematic mind, the scheme and details of this chapter are particularly addressed.

A word of warning, or, rather, a declaration of fact, is here in order. It is impossible to apply to the designing office the principles of efficiency which call for the greatest output in a given time. Men of imaginative mind, designers of originality, and inventors, are very frequently extremely unsystematic in their work and erratic as to their output. To try to gauge the worth of a man engaged on an important design by the number of days or weeks he spends on it, does not indicate a very broad understanding on the part of the management, when one considers that the expenditure of an additional week's thought or investigation on a problem of importance may result in savings of thousands of dollars in first cost and the final success of the enterprise, in place of otherwise inevitable failure.

Some lines of drafting (and even designing) have been so thoroughly systematized, however, that efficiency methods, speaking in the usual sense of the term, are already in force, and advantageously so; structural-steel work being a particular case in point.

SEC. I. OUTLINES FOR ENGINEERING DESIGNS

Outline for Engineer's Design for a Steel Mill Building

The following enumerations are intended as "reminders" to the engineer engaged in producing designs for a mill building for the purpose of obtaining bids on the material. It is supposed that the drawings and specifications are sufficiently complete, so that, while any special features desired are clearly shown or designed, yet the contractor is enabled to embody his own convenient sizes and details into as much of the work as possible, under the control of full and unmistakable specifications.

For "Outline of Specifications" for this design, see p. 103.

No rule can be laid down as to what items should appear on the drawing, and what in the specifications, convenience will govern in each case; but, in general, it should be noted that sizes, etc., given on the drawing should not be repeated in the specifications, and *vice versa*.

For a more complete and detailed list of material, such as must be considered by the contractor's engineer in preparing estimates on this class of work, see p. 263.

(1) **General**

Principal dimensions; lengths, breadths and heights.
Spacing of trusses for economy, etc.
Pitch of roof.
Spacing of purlins.
Monitors.
Future extensions.
Floors and galleries.
Cranes.
Details of old work to be joined to.
Shafting Supports.

(2) **Loads**

Dead load of structure.
Wind on structure (roofing, siding and frame).
Snow.
Arbitrary roof load.
Extra load to take care of corrosion.
Floor loads (live).
Crane loads; other machinery.
Future loads.
Initial stress in bracing.
Earthquake strains.
Erection stresses.
Loads on lower chords.

(3) **Structural Design**

Allowable Stresses: tensile, compression-formula, max. comp., shearing, shear and bending on shop and field rivets, comp. on concrete and brickwork.
Decrease of above for live loads.
Increase of same for wind strains.
Deduction for rivet-holes.
Plate-girder rules: flanges, webs, stiffeners, rivet-spacing, etc.
Combined stresses.
Crane Girders: top-flange rivets, connection to column for maximum shear, horizontal stiffness.
Crane Columns: eccentric loading, max. l/r, bracing.
Interferences: cranes, doors, windows, machinery.
Maximum l/r for main and secondary members.
Purlin spacing: framing around stacks, etc.
Siding framing: posts, girts, door and window framing.
Partition framing.
Punching of purlins, etc., for spiking-pieces.
Bracing: top-chord, bottom-chord, sway, longitudinal, monitor, knee bracing.
Struts: peak, eave, top-chord, bottom-chord, girt.
Tie rods: bottom-chord, floor.
Sag rods: roof and sides.
Finishing-angles.
Elevator-shaft framing.
Checkered-plate floors; expanded-metal for concrete floors.
Base-plates; area, thickness.
Anchor-bolts; net area, length, attachment to column, location.
Minimum thickness of metal; exception in case of webs of beams and channels.
Field connections; riveted or bolted or both.
To satisfy Building Laws, or Code of Nat. Board of Fire Underwriters.
Overhanging eaves; openings under same.

(4) **"Finishing" Work**

Corrugated Galvanized Steel (or Iron); thickness for roof, sides and partitions, fastenings for sheets to one another and to purlins and girts.
Other coverings. slate, tar-and-gravel, etc.
Sheathing for same; spiking-pieces.
Windows· fixed and sliding sash, shutter windows, 10 percent excess glass (to cover breakage in shipment), putty, etc.
Window operating devices. Window gratings or grilles.
Skylights.
Doors: plain, hardwood, sandwich, rolling-shutter, lift, sliding.
Flashing for windows, stacks, etc.
Cornice; ridge-roll; corner-boards; base-boards; thickness of metal for same.
Gutters and Leaders: size, and thickness of metal.
Louvers and Ventilators: shape, and thickness of metal.
Hardware: locks and keys.
Window-guards: Door-guards.
Railings; *Net* height.
Stairs and Ladders; Fire-escapes.
Elevator-shaft grilles.
Wire net for ventilating openings and tool-rooms.
Flagpole.

Outline for Design of a Steel Frame Office Building

I. General Considerations

Panel spacing for economy of completed floor; considering floor material, steel beams and girders (two and four concentrations most economical), construction of centering, influence of spandrels, location of foundations.

Location of Girders and Beams as influenced by above, and by headroom, ceiling paneling, location of permanent partitions, wind-bracing, connections to columns.

Spandrel Girders: to carry masonry, act as wind-bracing, form lintels; fireproofing required by Building Law, connection to columns.

Columns.—Type as influenced by details of beam and girder connections; change of section from top to bottom required by loads, heavy concentrations, etc.; influence of eccentric loading; mill or stock delivery of material; maximum size of fireproofed columns allowed by architect; wind strains; turn columns to secure best features as indicated by above.

Foundations.—See p. 60.

Column Bases.—Self-contained, cast iron, cast steel, built steel, or grillage—as influenced by cheapness, quickness of delivery, adaptation to foundation.

Retaining Wall Framing: Type best adapted to size, location, pressure and method of resisting top and bottom reactions.

Wind Bracing.—System to be adopted as influenced by height and dimensions of building and intensity of stress, space available in spandrels and interior walls, floor system.

II. Loads

(1) Dead Loads

(a) On Beams.
Floor finish; deadening; concrete, terra cotta, etc., floor-arches; haunches or other fireproofing; plaster or hung ceiling; spandrel walls; steel.
Also: permanent walls or partitions; concentrated loads from posts or hangers; cornices; tanks; future extensions; canopies; pent houses; vaults.

(b) On Girders.
Loads as for beams, and also haunches or other fireproofing for girders; girder steel.

(c) On Columns.
Loads as for girders, and also column fireproofing and steel; future floors.

(d) On Foundations.
Loads as for columns and also weight of foundation.

(2) Live Loads

(*a*) On Beams.
Specified live load; elevator load (L.L., weight of car, counter weights and impact); overhead runways; machinery loads; heavy safes; movable partitions (at pounds per square foot of floor); future loads.

(b) On Girders.
Same as for beams; note allowed reduction in specified L.L.

(c) On Columns.
Same as for beams; note allowed reduction in specified L.L ; future floors.

(d) On Foundations.
Same as for columns; note allowed reduction in specified L.L; future loads.

(3) **Wind Loads**
As specified by Building Law or otherwise. Effect on girders, columns, "X", knee or portal bracing, on girder connections, on foundations and anchor-bolts.

(4) **Earthquake Loads**
System of bracing used to resist earthquake loads

III. Structural Design

Allowable stresses: tensile, compression formula, maximum comp., shearing, shear and bending on shop and field rivets, bearing on concrete and masonry.
Decrease of above for live loads.
Increase of same for wind loads.
Combined stresses.
Plate girder rules: flanges, web, stiffeners, rivet-spacing, etc.
Columns: direct and eccentric stresses, bending stresses due to wind, etc.
Deduction of tension sections for rivet-holes.
Castings, specifications for.
Location of beam separators.

IV. Miscellaneous Framing and Details

Trusses.
Elevator-hatch framing: size to allow counterweights, inside sills, plungers, control ropes, etc. Overhead beams for strength and location.
Tank Platforms: spacing of beams, and strength for greatest load.
Cornice framing.
Spandrel supports.
Foundation Material (see p. 60).
Shelf angles on columns, beams, walls, etc , for joists, concrete arches, spandrel walls or for hooks of wall anchors.
Smoke-stack.
Flag-pole.
Skylight framing.
Wall anchors, masons' anchors, corner anchors, spandrel anchors.
Stairs.
Fire escapes.
Mullions.
Bulkhead framing (for store windows).
Pipe-space framing.
Balcony framing.
Pent-house framing.
Marquee framing.

Outline for Design of Steel Bridges (Reference)

The design of steel bridges, both railroad and highway, is so completely circumscribed by the various standard specifications in use, that a schedule of conditions to be observed is no great utility. The type of bridge selected is largely governed by the conditions presented, although judgment will usually have to be exercised in the choice; but, this matter decided, the remaining work is mostly routine, the specifications being consulted at every step.

As a **check on the estimate,** to guard against omission of any items

in "weighing-up" the bridge, the reader is referred to the schedules in Chap. VI, pp. 266 to 273.

Outline for Design of Mill Building Foundations

(1) **General Considerations affecting Type of Foundation**
- (a) Soil: bearing-power, ease of excavation.
- (b) Suitability of materials proposed as affected by workmen and machinery available; first cost; transportation facilities; permanency; influence of adjoining work; future work.

(2) **Types of Foundations**
- (a) Timber blocking.
- (b) Masonry: brick, stone, capstone.
- (c) Concrete: plain, reinforced.
- (d) Combination concrete and masonry.
- (e) Piling: wood, concrete, steel, screw-piles, pipe and concrete.

(3) **Calculations and Design**
- (a) Assumed safe pressures, on concrete, masonry, soil, piles, etc.; assumed safe strains on anchor-bolts, reinforcing-metal, etc.
- (b) Dead Loads: of structure, base, and future dead loads.
- (c) Live Loads: on roof and floors, cranes, machinery, wind, earthquake, future live loads.
- (d) Design of Steel Base-plates: area, thickness.
- (e) Design of Anchor-bolts: for uplift and shear, length in footing to develop strength, bottom connection.
- (f) Grillage: area for bearing, size for bending, bearing and shear, clearance between beams to allow concreting, separators, bolts. Set top below floor.
- (g) Design of Footing: area at base to withstand vertical load and load at toe from "overturning," weight and shape to resist upward pull at assumed f s., reinforcement for bending due to direct and indirect loads, masonry bases not to be in tension on windward side, depth to secure good bearing and to be below frost-line.
- (h) Design of Pile Foundations: safe load per pile, distance apart, size, amount of driving, cut-off.
- (i) Check by comparing summation of applied loads with total base area multiplied by unit pressure (will not apply to "overturning" bases)

(4) **The Drawing**
- (a) Center-lines, "surveyor's dimensions" (calculated diagonals), tie up with existing work, cardinal points
- (b) Dimensions of footings, location and height of anchor-bolts.
- (c) Adjoining work, interferences.
- (d) Column marks.
- (e) Notes, see (5).

(5) **Specifications** (or Notes)
- (a) Foundations to go down to good bearing "as engineer in field may direct" or otherwise; area of base to be modified if assumed safe loads on soil are not correct; bases not to be smaller than shown on account of weight necessary to withstand uplift.
- (b) Kind and Quality of Masonry.
- (c) Proportions of Concrete, and Grout.

(d) Note concerning certain (or all) bases being alike.
(e) Note concerning amount of concrete, etc., required.

Outline for Design of Foundations for a Steel Frame Office Building

(1) **General Considerations affecting Type of Foundation**
- (a) Safe bearing pressure on soil, and depth at which considered safe loadings are reached.
- (b) Addition to cost per increment of depths as influenced by:
  Greater excavation.
  Caisson methods.
  Water disposal, etc.
- (c) Influence of existing adjoining buildings and their foundations, and methods to be used for supporting same (by shoring and underpinning).
- (d) Influence of lot-line restrictions or party-wall contracts.
- (e) Effect of probable settlement, initial and final.
- (f) Effect of present and probable future elevation of water-table on piles and timber grillage.
- (g) Effect of upward reactions on piers from cantilever design.
- (h) Relative costs of materials and methods outlined below.

(2) **Types and Methods of Foundation Construction**
- (a) Simple Masonry Footings of offset courses on concrete, R. C. or wood footing-courses.
- (b) Wooden Pile Foundations capped with concrete, R. C., wood or steel grillage, etc., on the distributed or a concentrated load system, or to compress a weak soil.
- (c) Concrete Pile Foundations used same as (b).
- (d) Concrete-filled Pipe Piles, of wrought or cast iron:
  Sectional (for underpinning).
  Well-casing piles, with internal reinforcing rods, driven with well-drilling tools, for difficult boulder formations.
  Capping of concrete, R. C., grillage, etc.
- (e) Timber Grillage Foundations.
- (f) Grillage Foundations of steel beams encased in concrete, in separate or combined footings; waterproofing.
- (g) Reinforced Concrete Footings, separate or combined; waterproofing.
- (h) Open Caissons: of wood, steel, R C. or C. I.; circular or rectangular; driven from surface or built below; spread base; concrete or masonry filled; capping of masonry, grillage, or C. I., or structural steel base.
- (i) Pneumatic Caissons: of wood, steel or wood and steel; circular or rectangular; independent or connecting (forming an open caisson); concrete or masonry filled; capping of masonry, grillage, or C. I., or structural steel base.

(3) **Calculations and Design**
- (a) Assumed safe pressures on concrete, masonry, soil, piles, etc.; assumed safe stresses on anchor-bolts, grillage-beams, reinforcing bars; compression on concrete in beams.
- (b) Dead Loads: of structure, foundations and future dead loads (see p. 57).
- (c) Live Loads: roof, floor, elevator, wind, machinery, earthquake, etc., and future live loads; proper reductions on same (see p. 57).

(d) Design of Column Base: area and thickness of base-plate; height and thickness of wing-plates and stiffeners and rivets in same; size of angles, metal to come on top of grillage webs.
(e) Design of Cast Iron or Cast-steel Base Plates: area of top and bottom surfaces, height as proportioned to same; minimum thickness of metal; location of ribs; calculation of cross-section for tensile stress and redesign if necessary, edge lips; holes for column bolts, for grouting and for removal of core; elevation of top. Alternate; steel slab or grillage.
(f) Design of Grillage: area for bearing (counting top flanges if encased in concrete); size of beams for bending, shear and bearing on web; clearance between beams for concreting; beams to come under column metal; gas-pipe, cast or riveted separators; bolts; elevation of top to be *below* floor line; waterproofing of footing.
(g) Design of Combined Footings: center-of-gravity of applied loads to coincide with c.g of footing area; required area of footing; restrictions due to lot-lines, etc ; rectangular or trapezoidal footings; soil pressure to be uniform; calculation of lower course of beams as per (f) above; calculation of upper course as per (f) above for special loadings, for R. C. footings see (i) below.
(h) Design of Masonry and Plain Concrete Footings: area at base to withstand applied load and weight of footing; depth as determined by allowed offsets of courses.
(i) Design of Reinforced Concrete Footings: area of base to withstand applied load and weight of footing; depth as limited by soil conditions and proportion of footing; design of sections for bending and shear; reinforcement in top; use of bars to be of stock sizes and as uniform as possible for the job; bars to be spaced far enough apart to allow placing of concrete in reversed girders; waterproofing.
(j) Design of Pile Foundations: safe load per pile, distance apart, size, amount of driving, cut-off.
(k) Check by comparing summation of applied loads to summation of footing area multiplied by bearing pressure

4) **The Drawing**
(a) Center-lines; angles; tie up with building and lot-lines and existing work; "surveyor's dimensions" (calculated diagonals).
(b) Cardinal points.
(c) Dimensions of footings, location and height of anchor-bolts, sizes and location of grillage-beams, reinforcing metal, elevations referred to datum, sufficient elevation views.
(d) Adjoining work, interferences.
(e) Column marks.
(f) Notes as below.

5) **Specifications** (or Notes)
(a) Foundations to go down to good bearing "as engineer in field may direct" or otherwise.
(b) Kind and quality of Masonry.
(c) Proportions of Concrete, and Grout.
(d) Specifications for Piling.
(e) Specifications for Caisson Sinking.
(f) Specifications for Waterproofing.
(g) Note concerning certain (or all) bases being alike.
(h) Note concerning approximate amounts of material required.

Outline for Design of Machinery Foundations

(1) **General Considerations affecting Type of Foundation**
- (a) Soil: bearing-power, ease of excavation
- (b) Suitability of materials proposed as affected by workmen and machinery available; first cost; transportation facilities; permanency; influence of adjoining work; future work.

(2) **Types of Foundations**
- (a) Timber blocking.
- (b) Masonry: brick, stone, capstone.
- (c) Concrete: plain, reinforced.
- (d) Combination concrete and masonry.
- (e) Piling: wood, concrete, pipe and concrete.

(3) **Calculations and Design**
- (a) In general, design will be governed by experience and judgment.
- (b) Depth of Foundation; fixed by bearing obtainable, and by required weight of foundation.
- (c) Area of base; fixed by safe load on soil, and by required "spread" for stability
- (d) Weight of base; dependent on character of machinery.
- (e) Spread footing-course.
- (f) Sand "cushion" footings to prevent vibration.
- (g) Special foundations; steam-hammer, etc.

(4) **Details**
- (a) Anchor-bolts to be free at tops; set right height; to be entirely removable on large work, with tunnels and hand-holes to bottom washers.
- (b) Provide all required pits and tunnels, and give access to same.
- (c) Provide drains from all pits and tunnels.
- (d) Provide openings for all exhaust-pipes, elbows, etc.
- (e) Provide ledges for floors; avoid "tripping steps" at dangerous places.
- (f) Allow for grouting, and word drawing so that there can be no mistake as to final height of machine.
- (g) Provide wood "dead-men" between bed-plate and masonry for machinery subject to shock.

(5) **The Drawing**
- (a) Main and detail dimensions to be correct, and complete; tie up with existing work.
- (b) Dimensions of foundation; location and height of anchor-bolst.
- (c) Adjoining work; interferences.
- (d) Notes, see (6).

(6) **Specifications** (or Notes)
- (a) Foundations to go down to good bearing "as engineer in field may direct" or otherwise.
- (b) Kind and Quality of masonry.
- (c) Proportions of Concrete, and Grout.
- (d) Quantity of materials required.

Outline for Small Tank Designs

Note.—This outline is intended to cover the design of miscellaneous tanks inside a factory, etc. For larger and elevated tanks, see outlines on pp. 64 and 65 respectively.

(1) **General Considerations**
- (a) Best shape and size of tank for use intended or for future requirements: cylindrical, rectangular, conical bottom, hemispherical bottom, suspended, etc.
- (b) Influence of material to be confined on shape and materials of construction; acids, alkalis, etc.
- (c) Adaptability for cleaning; are internal braces allowable?
- (d) Adaptability for ease of repair.
- (e) Adaptability for future extension
- (f) Staging: height, design, future extension, other loads.

(2) **Size**
- (a) Capacity for use intended or for future requirements.
- (b) Width, length and depth to go in space available.
- (c) Proper depth for special requirements (constant head, etc.)
- (d) Clearances required in shipment, whether shipped "knocked down" or "riveted up."

(3) **Material**
- (a) Shell: steel, iron, C. I., galvanized steel or iron, copper, lead, wood, etc.
- (b) Bracing: rim angles; stiffening angles on top, sides and bottom; internal bracing, rods, flats, angles, etc ; gusset plates.
- (c) Fittings: supporting lugs, angles, hangers, etc.; rivets; entrance, discharge and overflow connections; sumps; gratings and screens; gauge-glasses; man- and hand-hole covers; other fittings.
- (d) Staging: structural steel, wood.

(4) **Strength**
- (a) Shell. thickness of metal for sides, bottom, partitions and cover; unsupported surfaces. Efficiencies of joints. Spacing of supporting beams in relation to thickness of bottom.
- (b) Bracing: rim angles; stiffening angles on sides, bottom and top; internal bracing, rods, flats, angles, etc.; horizontal circular girders (for conical-bottom tanks); gusset plates (for flat heads).
- (c) Fittings: supporting lugs, angles, hangers, etc.; reinforcing plates.
- (d) Riveting: size of rivets, type of joint, pitch, lap, etc.; countersunk rivets on inside or outside?
- (e) Staging; for present and future loads.

(5) **Details**
- (a) Openings: supply; discharge; overflow; sumps; washout; manholes; hand-holes; valves; screens.
- (b) Partitions: location; height; openings in.
- (c) Machinery, for stirring, etc.; attachments to tank; clearances for, etc.; see p. 80.
- (d) Miscellaneous Fittings: gauge-glasses; thermometers; tell-tale; ladders, inside and outside; hatch covers in top; "blow-up" piping.

(6) **Check drawing for**
- (a) Correct placing of views.
- (b) Sufficient views.
- (c) Sufficient detail.
- (d) See if drawing may not have to be done all over again.
- (e) Correctness of notes and titles.
- (f) Completeness of notes and titles.
- (g) Agreement with specifications.
- (h) Schedule of orders; number of items required, and marks.

Outline for Design of a Large Steel Tank

Intended to cover design of large steel tanks for storing oil, water, molasses, etc.; resting on the ground (on concrete surface).

(1) **Size**
- (a) Reduce capacity in gallons to cubic feet, after ascertaining whether U. S. or Imperial gallons are specified.
- (b) Proportion diameter and height to obtain most economical tank. (H : D = 1 : 1 for 20 ft. diameter; 1/2 : 1 for 75 ft. diameter, about.)
- (c) Diameter and height in relation to space available for tank.

(2) **General Arrangement**
- (a) Roof to be self-supporting (dished to radius equal to diameter), supported on trusses, on trusses with one central column, or on rafters with concentric rows of columns; black or galvanized sheets.
- (b) Material of roof posts; structural shapes, pipe (plain, galvanized, or filled with concrete).
- (c) Roof plates to be sectors.
- (d) Bottom plates to be rectangular.
- (e) Shell plates to be in courses 3/4/5 ft. high.

(3) **Strength**
- (a) Bottom: empirically fixed at from 3/16 in. to 1/2 in. depending on size and character of job, usually 1/4 to 3/8 in.; size and rivets, joint (S. L. R.), pitch, lap.
- (b) Shell: weight of liquid per cubic foot, stress per lineal inch at bottom of each course, efficiency of joint, allowable stress per square inch on net section, required thickness of metal; additional thickness to take care of rust or corrosion; top courses not less than (3/16 in.) thick; design of joint for required efficiency, size of rivets, style of seam, pitch, lap, etc., or simply state required efficiency and check contractor's design of joint.
- (c) Roof: dished top plates proportionate to diameter (from 1/8 in. for 30 ft. to 1/4 in. for 75 ft. diameter); supported roof plates should support weight of a man on chosen span (usually No. 10); trusses and rafters figured for load of (—) lb. per square foot; minimum thickness of truss-material to resist corrosion.
- (d) Angle Rims: top angle to resist distortion, proportionate to size of tank; bottom angle (or angles) proportionate to material of bottom and sides, rivets to carry weight of steel sides, bearing area for safe load on concrete.

(4) **Details**
- (a) Ladder inside and out.
- (b) Tell-tale: float, chain, wheels, indicator, scale.
- (c) Inlet nozzle: caulking strip, size and drilling of flange.
- (d) Discharge nozzle: caulking strip, size and drilling of flange, screen over on inside.
- (e) Overflow.
- (f) Manholes: in roof and shell, reinforcing for latter.
- (g) Blowout pipes in bottom connected to a single blow-off valve.
- (h) Vent in roof: finial.

(5) **Check Drawing for**
- (a) Correct placing of views, especially of location of all openings in plan.
- (b) Sufficient views.

(c) Sufficient detail.
(d) Correctness and completeness as per above schedule.
(e) Correctness and completeness of notes and titles.
(f) Agreement with specifications.
(g) Number of units required, and marks.

Outline for Design of an Elevated Steel Tank

(1) **Style and General Arrangement**
- (a) Hemispherical-bottom tank with columns attached to shell plates.
- (b) Conical or segmental bottom tank with horizontal circular girder at joint; load taken to columns by brackets on shell plates, or on extension of latter down below joint.
- (c) Flat-bottomed tank resting on steel beams; load taken to columns by girders under.
- (d) Style of Roof: plates dished to radius equal to diameter of tank; conical or pyramidal shape, carried on rafters or trusses; pagoda shaped; of wood; finial.
- (e) Style of Tower: four, six, eight, etc., posts; consider use of four posts with two braces at top of each, giving twelve points of support; economy of small number; bracing of angles or of adjustable rods; choice of column section.
- (f) Platform at bottom of tank; horizontal girder (of conical-bottom tanks) usually designed for this purpose.

(2) **Principal Dimensions**
- (a) Tank: reduce capacity in gallons to cubic feet after ascertaining whether U. S. or Imperial gallons are specified; proportion diameter and height for economy, appearance and ease of fabrication (details).
- (b) Tower: height from bottom of steel of column to *bottom point* of tank; columns battered or vertical; spread at base and space available for same.

(3) **Strength**
- (a) Live Load: weight of liquid per cubic foot, stress per lineal inch at bottom of each course.
- (b) Hemispherical Bottom: stress per lineal inch, efficiency of joint (usually S.L.R.); thickness required for stress, and for practical construction (not less than No. 10); sizes of rivets, pitch and lap; thrust of inclined posts to be resisted by a horizontal girder (single angle for small tanks.)
- (c) Conical or Segmental Bottom: stress per lineal inch for circumferential and for longitudinal joints; efficiency of joint; thickness required for stress, and for practical construction (not less than No. 10); size of rivets. pitch and lap; horizontal girder, compression in due to load, moment in due to thrust of inclined posts.
- (d) Flat Bottom: thickness as determined by load and spacing of beams (B.M. = $WL^2/15$); efficiency of joint, size of rivets, pitch and lap; additional thickness for rust.
- (e) Shell.—See p. 64 (3b).
- (f) Roof.—See p. 64 (3c).
- (g) Tower.—Dead, live and wind loads; allowable unit stresses for each; max. l/r for columns and struts; rivet values; horizontal bracing; size of base-plates, anchor-bolts.

(4) **Details**

See p. 64 (4-a to h.)

- (i) Inlet Pipe.—Stuffing-box (to take care of movement), base elbow or tee, valve, lagging (for protection from frost).

(j) Platform.—Brackets, floor, railing.
(k) Swinging Discharge Spout (for Locomotive Supply Tanks).—Spout, counterbalance, discharge-pipe, valve, handle, supports.

. (5) **Check Drawing for**
See p. 64 (5).

Outline for Piping Designs and Drawings

Note.—This outline is intended for use in connection with installations of steam, exhaust, boiler-feed, juice and similar piping.

It is supposed that complete "plan and elevation drawings," to scale, will be made by the engineers, giving center-to-center and other principal dimensions, but omitting detail figures dependent on the dimensions of the fittings, which are left to the pipe contractor. Furthermore, it is supposed that the material is ordered from a detail list and accompanying specification such as is illustrated on pp. 122 and 124, and that few or no general notes are placed on the drawing, but are covered by the specifications.

The first six sections are for the use of the engineer in preparing the preliminary single-line drawing and the notes to be submitted to the draftsman; the last section is intended to aid the draftsman and checker in producing the finished design drawing.

(1) **General Arangement**

The conditions governing the system to be adopted for steam, exhaust, boiler-feed, blow-off, vacuum, oil-supply, drip, juice, etc., piping are so multitudinous that no attempt will be made to cover them in detail. A few general principles, only, will be enumerated, which apply, more or less, to all lay-outs.

(a) Lay out so that repairs can be made without interfering with the regular service of the plant, *i.e.*, on a system that will avoid shut-downs, or repair-making at night.
(b) The system to be suited to the required continuity of service and hours per day the plant is in operation; *i.e.*, bear in mind the proportionate seriousness of a shut-down, and put in a system that will either avoid it entirely or restrict in to a few hours duration, as the conditions may warrant.
(c) Bear in mind the principle that, in steam plants, more particularly, the choice of size of units and the choice of piping arrangements should be concurrent operations; the mere connection, by piping, of arbitrarily fixed units, is not "engineering."
(d) Typical Piping Systems

I. A straight-line header connecting a row of boilers and a row of engines. Cheap but very poor; repairs to the main involve a complete shut-down of the plant.

II. The " Double Main" system, involving a duplication of the piping of No. I.

III. The "Loop" system; which may be briefly described as a connection of the ends of the single header of No. I.

IV. The "Division" system; *e.g.*, a row of engines opposite a row of boilers, each connected to a steam header running between and parallel to them; by choice of size of units suitable to class of load, portions of main may be shut off for repairs at times of light load.

V. The "Multiple Units" system; several groups of complete units (engines and boilers) capable both of independent operation, or, by an auxiliary header, of cross connection or grouping into a collective plant. Expensive, but very flexible and adapted to continuous operation and large plants.

(e) Design so that the piping and choice of vital auxiliaries is on a system consistent with that of main apparatus; *i.e.*, so that a break-down in the auxiliary plant will not shut down the station.

(f) Non-vital auxiliaries (condensers, heaters, etc.) should be arranged for double service in case of trouble, in preference to total loss of service to a portion of the plant; *e.g.*, one condenser doing the work of two at a lower vacuum is preferable to a portion of the plant exhausting to atmosphere.

(g) For superheated steam piping; lines to be short, size of pipe small (to secure velocities of 6,000 to 10,000 F.P.M. and small radiation losses), lines to be free from abrupt turns, drips at all low-velocity points, large receivers and separators not to be used.

(h) Special requirements in design of air, massecuite or other special piping

(i) Make scale diagram of elevations, so that matters of headroom, lifts of pumps, drains for steam, exhaust and oil piping, etc , may be readily seen.

(j) Place large steam and exhaust (or similar) mains at different elevations, so that cross-overs may be made without bending branch pipes.

(k) Miscellaneous Details.
Location of Anchors, Expansion Joints, Steam Receivers, Separators, Drips, Traps.

(2) **Pressure**

State pressure to be carried on each line; pressure to which pressure-regulators are to reduce.

(3) **Size of Piping**

(a) Steam Piping.—Diameters for allowed velocity; effect of elbows, etc.; sizes of branches to suit the cylinder size; size of main in proportion to size and number of branches; allowance for additional boilers, etc.

(b) Exhaust Piping.—(Same as for Steam Piping).

(c) Water, Juice, Etc., Piping.—Diameters for allowed velocity; effect of elbows, valves, etc.; size of mains in proportion to size and number of branches; allowance for future increase.

(4) **Materials**

(a) Pipe.—Cast iron; wrought steel; wrought iron; "guaranteed" wrought iron; spiral-riveted; riveted steel; brass; copper; galvanized wrought iron; lead; lead lined; copper lined; enameled wrought iron; "dipped" pipe.

(b) Fittings.—Cast iron; semi-steel; malleable iron; brass; cast steel.

(5) **Type and Weight of Pipe and Fittings**

(a) Cast-iron Pipe.—Bell and Spigot, universal, flanged, or other type of joint. Light, medium, heavy or extra heavy weight (thickness must be given).

(b) Wrought-iron Pipe.—Screwed, flanged or other type of joint. (Note —In case of flanged joint, state whether flange is to be ordinary screwed; screwed, pened and faced; welded; Vanstone; or of other type.)
Standard, "full-weight" standard, extra-heavy, double extra-heavy or other weight.

(c) Spiral Riveted Pipe.

(d) Riveted Pipe.—Flanged, lap-riveted, butt-riveted, or other type of joint.

Give thickness of metal and design of longitudinal joint (or state test-pressure).

(e) Brass Pipe.—Screwed, (brass) flanged, (or other type of joint). For flanged joints state if peening, sweating, etc., is required.
State whether "Iron-pipe" size, or give gauge.

(f) Copper Pipe.—State construction of (flanged) joint required (loose flange or brazed). Seamless drawn or brazed pipe.
Gauge of metal.

(g) Valves.—Screwed, flanged, bell or other type of end. Globe, angle, gate (Q.O., I.S , or O S. and Y.), check (ball swing, balanced, etc), hydraulic, lead-seat, or other type. Light weight, standard, medium, extra-heavy, or other weight.

(h) Other Fittings.—Screwed, flanged, bell or other type of end. Long-radius fittings.
Light weight (for spiral-riveted piping), standard, extra heavy or other weight.

(6) **Miscellaneous.**—Pipe brackets and hangers.
Joint drilling (*A. S. M. E.* Std or other)

(7) **Check drawing for**

(a) General desirability of arrangement, for present and future requirements; location of anchors and expansion joints.
(b) Simplicity and repetition
(c) Correct placing of views and sections
(d) Completeness of views and sections.
(e) Interferences with other piping, beams, and cols., knee-braces, doors, machinery, etc ; removal of pump plungers and engine pistons.
(f) Checks details for, (1) Correctness; diameter of flanges, diameter of bolt-circles, size of flange-bolts and holes, holes straddling centres, junction with other piping. (2) Completeness; all dimensions, sizes and descriptions.
(g) Check marks for correctness and completeness (compare schedule; see p. 503)
(h) General Notes.—Marks, references to other drawings. (Other notes should be given in specifications).

Outline for Design of Mechanical Transmission Systems

Note.—The following classification is not entirely logical, but it is believed that the arrangement will be found the most convenient for the majority of users.

(1) **Choice of System**

(a) Line-shafts driven by belts from a jack-shaft.
(b) Line-shafts driven by ropes from flywheel direct or through counter-shaft.
(c) Line-shafts driven by separate motors (Group drive).
(d) Individual motor drives.
(e) Long-distance wire-rope transmission.
(f) Reciprocating rods or wire-ropes (for pumping, etc., only).
(g) Chain drives.
(h) Gearing.
(i) Influence of future extensions and requirements.

(2) **Line-shafts**

(a) Size for present and future requirements.
(b) Supports not too far apart (10 ft. max.), and to be close to large pulleys.

(c) Ends to take future couplings.
(d) Speed fast enough to give small pulleys, slow enough to give safe belt-speeds.
(e) Locate so as to avoid vertical drives, and to get tight side of belts on lower sides.
(f) Clearances
(g) Flange or compression couplings; collars.
(h) Supports, wood or steel stringers or frames.

(3) **Pulleys**
(a) Diameter to give proper speed, and safe belt-speed (not more than about 4,000 f.p.m.); width to give safe belt strains. Ratio between diameters of two pulleys not to exceed 5 or 6 to 1. Standard sizes; for single or double belt.
(b) Material: cast-iron (for single or double belt), wood, pressed steel.
(c) Solid or Split, latter necessary on line-shafts.
(d) Right-angle Drives (quarter twist belt); belt to run on pulley in the plane of the pulley.
(e) Length of drive: not more than about 15 ft. for narrow belts, 20 to 30 ft. for wider belts.
(f) Keyways.
(g) Size of hub in relation to size of shaft (especially with split pressed-steel pulleys).
(h) Special Pulley Arrangements: binder frames (for right-angle drives); guide pulleys; belt-tighteners; mule pulleys.

(4) **Belts**
(a) Material. leather, rubber, balata, etc.
(b) Width; Speed; Single or Double; Centrifugal tension at high speeds.
(c) Least diameter of pulley.
(d) Tight side of belt in bottom.
(e) Splices.

(5) **Hangers and Boxes**
(a) Type of Hanger: drop, post or bracket.
(b) Type of Pillow-block: common, post, wall, etc.; floor-stands for same.
(c) Drop or reach sufficient to give clearances.
(d) Details: ring-oiling, ball and socket, solid boxes, babbited boxes, side adjustments.

(6) **Rope Driving (Manila or Cotton Rope)**
(A) System.—English (a number of separate ropes lying side by side in grooves), or American (one rope wrapped several times around the pulleys, tension being maintained by a weighted return-pulley). Former uses large ropes and is adapted to the largest installations; latter uses smaller rope and is more generally adopted by American engineers.
(B) Limiting Conditions.
  (a) Horizontal distance between shafts, shortest limits 20 to 40 ft., longest limits 100 to 160 ft., as affected by diameter of pulleys and sag.
  (b) Least diameter of pulley 30 to 40 times diameter of rope.
  (c) Usual size of ropes, 7/8 to 1 3/4 in. in diameter, limits 1/2 to 2 1/4 in.
  (d) Speeds of ropes 4,000 to 5,000 ft. per minute for large rope drives, 2,500 to 6,000 ft. for intermediate drives; best usual speed 4,800 ft. per minute.
  (e) Safe working load on rope (see tables in Kent, etc.).
  (f) A take-up sheave (Am. System) for not more than ten ropes.

(7) **Individual Motor Drives**
- (a) Sizes of individual motors.
- (b) Speed changes required by tools, and as supplied by style of motor considered.
- (c) Load-factor for whole installation. Friction loss at full-load, and no-load (both at — percent time factor).
- (d) Effect of A.C. induction motor service on a combined light and power circuit.
- (e) Size, type and cost of transformers.
- (f) Comparative cost of A.C. and D.C. installations.
- (g) Motor details: mounting, reduction gearing, chain drive, enclosures (screen, weather-proof, dust-proof, etc.), controllers.
- (h) Countershafts, belting, etc.
- (i) Wiring installation.

(8) **Group Drive (Each Line-shaft Driven by Motor)**
- (a) Horse-power required by each tool, and for transmission system (for full-load and no-load friction)
- (b) Load factor assumed. Size of Motor.
- (c) Effect of A.C. induction motor service on a combined light and power circuit.
- (d) Size, type and cost of transformers.
- (e) Comparative cost of A.C. and D.C. installations.
- (f) Motor details: mounting, speed reduction, enclosing (screens, moisture-proof, dust-proof, etc).
- (g) Shafting, hangers, belting, etc.
- (h) Wiring installation.

(9) **Link-belt Chain Drives**
- (a) Distance c. to c. of shafts not to be less than one and one-half times diameter of large sprocket; not to exceed about 12 ft. unless supporting pulleys are used.
- (b) Diameter of smallest sprocket to be not less than 10 or 12 teeth (for ordinary conditions).
- (c) Ratio of sprocket diameters not to exceed about 1:4 or 5, 1:3 preferable.
- (d) Drive not to be vertical unless a take-up is used.
- (e) Speed of chain not to exceed 500 ft. per minute for link-belt chains (400 preferable); 1,000 f.p.m. for finished steel roller chains (800 preferable).
- (f) Factor of safety dependent on speed, shock and dirtiness of working conditions, for good conditions from 6 at 200 f.p.m. to 12 at 500 f.p.m. and 20 at 700 f.p.m., increased as service may require.
- (g) If an idler is used on reverse side of chain, see that attachments will not foul.

(10) **Spur Gearing**
- (a) Power to be transmitted; assumed efficiency; speed-reduction diagram showing speed ratios, velocity of pitch circles, radial forces
- (b) Material for teeth, C.I., steel, etc.; assumed working stress at the various velocities.
- (c) Pitch and face of gears as calculated, and as finally adopted. Minimum number of teeth in pinions.
- (d) Form of tooth: cycloidal or involute? straight or twisted?
- (e) Other details.—Is circular or chordal pitch used? Depth of teeth, addendum, etc.
- (f) Material of spiders.
- (g) Diameter of shafts, length of hubs, size and type of keys.
- (h) Design of arms, rim, bolts, shrouding, etc.

Outline for Design of a Belt, Slat or Scraper Conveyor

For data to be submitted for obtaining a design and estimate on an installation of this character, see p. 184.

(1) **General Considerations.**—Choice of type of conveyor as affected by:
- (a) Material conveyed; its weight, bulk, destructive qualities, peculiar behavior on sliding surfaces, etc.
- (b) Quantity conveyed, capacity of type of conveyor.
- (c) Probable increase in capacity, or extension of conveyor.
- (d) Whether material is to be weighed (automatically or periodically) in transit.
- (e) First cost, as affected by special material and cost of lumber, etc.. for the rough construction.
- (f) Operating cost, including cost of labor, power and maintenance.
- (g) Life of conveyor and replacement cost.
- (h) Headroom, clearance, etc., required.
- (i) Maximum allowable slope for material to be conveyed.
- (j) Adaptation of conveyor to turning vertical or horizontal corners, considered also in connection with location of drive.
- (k) Power to be used, and possibility of obtaining speed reductions in a satisfactory manner.
- (l) Practicability of method of feeding material to conveyor; whether material is to be carried on upper or lower table or on both; necessity of returning material.
- (m) Requirements of switching material to other conveyors, and of final dumping of material.
- (n) Other considerations not covered by above.

(2) **Materials of Construction**
- (a) Belt: rubber, balata, "Scandinavian," canvas, leather.
- (b) Slats: wood (ash, maple, etc.), steel-plate (plain or apron), open-top buckets, cast iron.
- (c) Scrapers: wood, steel-plate, non-corrosive metal.
- (d) Conveying Chain: single or double; malleable iron, steel, bronze; link-belt, roller, pintle, monobar, etc.; consider wire-rope.
- (e) Track: steel angle, rails, etc.; bar on wood, wood.
- (f) Belt Carriers (Rollers): cast iron, pressed steel, pipe, wood.
- (g) Troughs: sheet steel, wood.
- (h) Sprockets: cast iron, cast steel, forged steel.
- (i) Gears: cast iron, cast steel, bronze, raw-hide, etc.
- (j) Supporting framework: structural steel, wood.
- (k) Galvanizing: for slats, chain, trough, etc.

(3) **Size and Strength**
- (a) Belt: width and ply.
- (b) Slats: length, width and thickness.
- (c) Scrapers: size, shape and thickness.
- (d) Conveying Chain or Rope: load, factor of safety, strength for future extension.
- (e) Track: strength under bending, stiffness under vibration or shock.
- (f) Driving Mechanism: size of chains and belts for load and speed; gearing; shafting; for present and future requirements.
- (g) Power: steam-engine, electric motor, line-shaft, etc.; for present and future requirements.
- (h) Supporting framework: size of members for strength and rigidity.

(4) **Details**
- (a) Main driving-sprockets or pulleys.
- (b) Tail sprockets (traction wheels) or pulleys, sprockets loose on shaft.
- (c) Take-ups.
- (d) Intermediate drives; use of belt, etc , for automatic stop when overloaded.
- (e) Gates: suitability, method of operation.
- (f) Trippers, switches, etc.
- (g) Chutes.
- (h) Clearances for scraper conveyors.

(5) **Check Drawing for**
- (a) Correct placing of views and sections.
- (b) Completeness of views and sections.
- (c) See if drawing may not have to be done all over again.
- (d) Simplicity of design.
- (e) Suitability of design as outlined under (1) above.
- (f) For suitability of materials of construction as outlined in (2) above.
- (g) For size and strength as per (3) above.
- (h) Main dimensions, correctness and completeness.
- (i) Interferences.
- (j) Detail dimensions, correctness and completeness.
- (k) Marks, for correctness and completeness.
- (l) General notes, titles, etc.

Outline for Design of Screw Conveyors

Note.—Practice differs as to the nomenclature of the two principal types of screw conveyors; it will be well, therefore, always to specify whether a "solid scroll" or a "ribbon" conveyor is required. the words "spiral," "screw" or "scroll" alone are ambiguous.

(1) **General Considerations and Design**
- (a) Types of Conveyors.
  The following are the types of spirals generally used: Solid scroll, ribbon, solid scroll with cut flights, double flight, solid scroll with intermediate mixing paddles.
- (b) Material of Spiral: steel plate (black), galvanized steel plate, cast iron (black or galvanized), extra heavy steel plate.
- (c) Material of Trough: steel plate (black or galvanized), wood box with curved steel lining, cast iron, concrete. Water-jacketed trough.
- (d) Choice of type and material, as affected by: weight, viscosity, stickiness, corrosive action, etc., of the material.
- (e) Travel of Material, Direction of Rotation, etc. See that the travel of the material, the direction of rotation and the "hand" of the spiral mutually agree.
- (f) Is the conveyor to be reversible?
- (g) Driving arrangement. Design for use of standard material, reversibility, separate control (by T. and L. pulleys or clutch); automatic shut-down (by a belt drive), etc.

(2) **Size and Strength**
- (a) Spiral.
  Diameter as affected by length of conveyor and maximum quantity of material handled; future extension; thickness of metal.

(b) Shaft.
Diameter as affected by length of conveyor and quantity of material handled; location of intermediate hangers; future extension; transmission through shaft to other apparatus.

(c) Trough.
Use standard size and design if possible on account of standard ends and intermediate hangers. Area to take care of maximum capacity; depth to avoid splashing; future capacity.

(d) Driving Gear.
Design for present and future loads, shock and wearing qualities; use standard material as far as possible. (See 1–g.)

(3) **Details**
- (a) Trough Supports: hangers, saddles, stands, etc.
- (b) Intermediate Hangers: renewable bearings, etc.
- (c) End Thrust Boxes.
- (d) Discharge Openings: end discharge, plain openings, simple steel slides (lengthways), rack-and-pinion slides, chutes.

(4) **Check Drawing for**
- (a) Correct placing of views and sections.
- (b) Completeness of views and sections.
- (c) See if drawing may not have to be done all over again.
- (d) Simplicity of design.
- (e) Suitability of design as outlined under (1) above.
- (f) For size and strength as outlined under (2) above.
- (g) For completeness and suitability of details as outlined under (3) above.
- (h) Main dimensions, correctness and completeness.
- (i) Interferences.
- (j) Detail dimensions, correctness and completeness.
- (k) Marks, for correctness and completeness.
- (l) General notes, titles, etc.

Outline for Design of a Self-supporting Steel Smokestack

(For outline of specification see p. 107).

(1) **Capacity**
- (a) Horse-power from *net* area and height.
- (b) Ratio of diameter to height as affecting economy of design.
- (c) Diameter of steel on inside of small courses.
- (d) Capacity for increase in size of plant.
- (e) Area of flue entrance(s).

(2) **General Arrangement**
- (a) Flue connected to shell: number of openings, required area, rectangular or oblong in shape, rim reinforcement, baffles.
- (b) Flue connected to masonry base: number of openings, required area, construction of arch, girder over opening to engage anchor-bolts.
- (c) Shape of base: bell-shaped (with "gore-shaped" plates, lapped or butt-strapped); frustrum of a cone; straight (extension of shell) with large brackets to take anchor-bolts (brackets of plate or trussing).
- (d) Type of base-ring: cast steel with bell bolted or riveted to it and anchor-bolts engaging ring only; cast iron with bell bolted or riveted to it and anchor-

bolts engaging brackets on plates of bell; the same with bell simply resting in groove in base ring; base-ring of angle-iron riveted to bell.

(e) Anchorage: bolts to be upset at top; two nuts with heavy washer under at top; anchor-washers of cast-iron or of built (structural) girder type; special girder to take anchor-bolt pull over flue opening (if in base).

(f) Arrangement of shell plates: alternate "large" and "small" courses maintaining a specified diameter for the whole height; uniform cone-shaped courses maintaining a specified diameter for whole height; cone-shaped courses reducing diameter by thickness of plates at each joint; uniform courses with butt-joints.

(g) Top Ornamentation: a "lotus" of (black or galvanized) plates on angle-iron frame; a cornice with top fencing or open fretwork; a platform supported by curved angle-braces with slat floor and heavy railing.

(h) Capping: one or two angle-irons, with or without cast-iron capping-ring, inverted channel-iron ring.

(i) Cleanout door and frame: in bell, or built in masonry footing.

(3) **Strength**

(a) Wind loads and stresses, dead loads of steel and lining; moments, etc.
(b) Thickness of shell at different levels.
(c) Rivet-spacing at different levels.
(d) Anchor-bolts, anchor-beams, bridge-girders over flue, etc , brackets on stack.
(e) Footing; design with area enough to give safe load on soil at toe, and heavy enough to resist overturning.
(f) Width of cast-iron base-plate.
(g) Reinforcing at flue-connection.

(4) **Details**

(a) Lining-supports; spacing, of angle or Z-bar.
(b) Internal vertical ribs (for stacks of large diameter).
(c) Painter's trolley and track.
(d) Ladder (of flats, pipe, or angle-iron).
(e) Clean-out door (see above).
(f) Lightning conductor and grounds.
(g) Rain shield (at roof).

(5) **Material**

Shell, base-plate, anchor-bolts, anchor-beams, lotus, platform, ladder, trolley, clean-out door, lightning-conductor and grounds.

(6) **Check Drawing for**

See p. 64 (5).

Outline for Boiler Design (Return-tubular)

(1) **General Considerations**

(a) Best type and size of boiler for use intended and for future requirements.
(b) Fire-tube or Water-tube; Return-tubular, Locomotive, Marine, etc., type.
(c) Transportation requirements.
(d) Kind of water to be used; fuel; change in fuel.
(e) Class of operating labor.
(f) First cost and upkeep; reliability.
(g) Adaptability to flue system.
(h) Cleaning tubes and interior of boiler.
(i) Facilities for repair.

(2) **Size**
- (a) Horse-power (from Heating Surface).
- (b) Diameter and Length (note limiting ratio of length of tubes to diameter); length to suit standard tube length.
- (c) Ratio of Heating Surface to Grate Surface.
- (d) Water capacity.
- (e) Steam-space capacity.
- (f) Size of Steam, Feed, and Blow-off Openings.
- (g) Safety-valve area.

(3) **Strength**
- (a) Shell: thickness of plate, efficiency of joints, detail of joints, size of rivets, lap, etc.; limiting thickness of plate, tensile strength of material.
- (b) Heads: as above; spacing of tubes vertically and horizontally, minimum spacing, distance from edge of plate; level of top of tubes
- (c) Tubes: size, length (limited as above), thickness, material.
- (d) Steam Drum: same considerations as for shell; connection to boiler.
- (e) Stays and Braces: size, number and detail.
- (f) Strengthening Rings (at man-holes and domes, etc.).

(4) **Boiler Supports**
- (a) Lugs: number, size and detail.
- (b) Hangers: number, size and detail.
- (c) Hanger-beams: strength, length and detail.
- (d) Supporting frame: material, size, strength, thickness, etc., to resist heat and corrosion, protection from heat.

(5) **Boiler Details**
- (a) Manholes: position, number, size, detail.
- (b) Handholes: position, number, size, detail.
- (c) Nozzles and Flanges: strength, simplicity, reliability, safety in shipment.
- (d) Feed-water Inlet: bushings, pipes, supports.
- (e) Blow-off: to be "extra heavy," location, fittings, connections.
- (f) Low-water Alarm: type, make, connection.
- (g) Water Column: cocks (design and levels), low- and high-water alarms, gauge-glass and connections, steam-gauge and syphon, connections to boiler.
- (h) Give flange drilling for all connections.
- (i) Dry-pipe.
- (j) Stop-valve.
- (k) Fusible Plug.
- (l) Injector; connections.
- (m) Feed Pump.

(6) **Brichin**
- (a) Area in relation to tube area.
- (b) Material; thickness of metal.
- (c) Attachment to flue.
- (d) Door.
- (e) Attachment to boiler.
- (f) Interferences.
- (g) Damper.
- (h) Details of construction.

(7) **Check Drawing for**
- (a) Correct placing of views.
- (b) Sufficient Views.

(c) Sufficient Detail.
(d) See if drawing may not have to be done all over again.
(e) Correctness of notes and titles
(f) Completeness of notes and titles.
(g) Agreement with specifications.
(h) Schedule of orders.

Outline for Design of a Three-motor Electric Overhead Traveling Crane

Although these machines are articles of standard manufacture it frequently happens that firms with machine-shop facilities desire to fabricate an overhead traveling crane for use in their own establishment, usually in the course of a lull in their regular business. The wire-rope, gears, motors and controllers will be selected and purchased from standard stocks; the blocks, also, may be purchased outside; and the bridge girders may be procured from a bridge shop if necessary; but all other parts can be readily fabricated, and the whole assembled, in the average machine shop.

The following reminders outline the general scheme of the design, and indicate possible variations.

(1) **Capacity and Principal Dimensions**
- (a) Live Load: carried on one or two trolleys, capacity of each; possible occasional overload.
- (b) Span, centre-to-centre of rails.
- (c) Lift: highest point of hook, lowest point.
- (d) Clearances: overhead, side, end of trolley, at knee-braces, at ends of runway, at doorways (when crane runs out of building), required by cage.
- (e) Trolley travel, extremes of hook positions
- (f) Length of runway.
- (g) Location of operator's cage.
- (h) Section of track rails.
- (i) Speeds required for hoist, trolley traverse and bridge traverse; at full and light loads respectively.
- (j) Voltage of current: direct or alternating; if the latter, ascertain also phase and frequency.
- (k) Type of motor to be used.
- (l) Position of existing or proposed line wires.
- (m) Other considerations: strength of existing track girders and supports; old material to be worked into the design; influence of shop facilities on design of bridge girders, carriages, etc.

(2) **Design of Hoist**
- (a) Loads: live, weight of lower block, overload, impact.
- (b) Use of Chain or Wire Rope: unit stress adopted.
- (c) Arrangement of Tackle: number of "falls" required, single- or double-grooved (R. and L.) drum (latter preferable).
- (d) Design of Bottom Block: hook, links, pins, size of sheaves, ball-bearings for hook, guards.
- (e) Design of Drum: diameter and effective length, grooving, thickness of metal, attachment of hoisting rope.

(f) Arrangement of Reduction Gearing: assumed friction loss; speed and radial-force diagram; assumed diameter of gears; size and speed of motor.
(g) Design of Gears: required pitch and face, commercial sizes to be chosen.
(h) Design of Shafts: for bending, shear and torsion; size of journals.
(i) Brakes: mechanical (Weston) and electrical.

(3) **Design of Trolley**
(a) Cast iron or Structural Steel Frame.
(b) Trolley Wheels: diameter, tread, material, roller bearings.
(c) Design of Trolley Traverse: speed, wheel load, tractive force, power required, speed and force diagram, choice of gears and shafts (as above).
(d) Arrangement of Mechanism so as to secure a compact but accessible trolley. Distance c. to c. of rails (*i.e.*, girders) sufficient to allow lower block turning when at high position.

(4) **Design of Bridge Girders**
(a) Form of Girder: simple I-beam; I-beam with horizontal channel on top; plate girder, of straight or "bellied" shape, reinforced or trussed top-chord; box-girder; riveted trusses.
(b) Gangway Construction knee-braces from main girders, auxiliary trusses, on one or both sides
(c) Loads: dead, live, overload, impact.
(d) Unit Stresses: top flange, bottom flange, web shear at end, on rivets, on field rivets or bolts at (centre) splice, allowable deflection, allowable l/r for top and bottom chords.
(e) Depth of Girder: at middle, at ends.
(f) Design of Sections: for strength, for deflection, for l/r.
(g) Details: stiffeners; end reinforcing-plates; splices; trolley rails, clips and stops.

(5) **Design of End Trucks and Bridge Traverse**
(a) Material for End trucks: cast iron or structural steel.
(b) Wheel-base required. Wheels, diameter, tread, material, roller bearings; axles.
(c) Strength and size of End Carriages, attachment of bridge-girders, bracing.
(d) Design of Bridge Traverse mechanism; force of traction, size and speed of motor, speed-reduction diagram (as above, for hoist), proportion of parts, squaring-shaft, brackets for same.

(6) **Miscellaneous Details**
(a) Cab: position for clearance and utility, of steel or wood construction.
(b) Housing: for outdoor service, dust or safety, for trolley, end-trucks and cab.
(c) Electric Wiring: bridge wires, controllers, electric-brake connection, fuses, switch, supports, trolleys, insulators.

Investigation of Strength of Old Steel Bridges

In order that a report may be made on the security of an old bridge, it is necessary that a more or less complete computation be made of the strength of the members, and that the results be considered in connection with the deterioration which has taken place in them.

In some cases the vibration or sagging of the bridge under traffic will call for immediate strengthening or condemnation; but in most cases the examination will be made for the purpose of ascertaining its capacity to carry increased loads, or to indicate the reinforcement necessary for the same purpose.

The steps to be taken in such an investigation will be about as follows:

(1) In case **detail drawings** of the bridge are on hand, take them to the site and compare thoroughly with the existing structure, so as to be sure that the construction is actually as shown on the drawings. At all points where deterioration has taken place, such as at the foot of end-posts, at all pin joints, stringer connections, pedestals, etc , estimate the reduction in section and note on the drawing, so that the proper deduction may be made from the original area when calculating the strength.

(2) In case the original detail drawings are not procurable, a sufficient number of **sketches** must be made in the field to (practically) reproduce them, account being taken of deterioration as described above. This work should be done by an experienced designer and detailer, and he should pay particular attention to such matters as, the number of rivet-holes which reduce the area of a tension member, the perfection of the butting connection of a compression member, size and spacing of batten-plates, etc., expanding his detail drawings in such cases so that there may be no doubt as to the exact construction at these points.

(3) Note **when,** and by what company, the bridge was **constructed**; and ascertain whether it is built of **iron or steel.**

(4) Take **photographs** of the bridge as a whole, and of a sufficient number of joints, etc., so that a good idea may be preserved as to the condition of the structure.

(5) Observe the **action** of the bridge **under traffic,** for deflection and swaying; take measurements if possible or desirable.

(6) Examine and report on the **condition** of the structure according to the items of "Inspection of Old Bridges" given on p. 327.

(7) Prepare an outline **design drawing** of the bridge just as would be done for a new structure.

(8) Having chosen a standard specification on which to compare the design, and having chosen the live loads for which it is desired to **investigate the strength** of the bridge, calculate for each member and detail the load which will actually come on it and the unit stress thus produced.
Calculate also the allowable stress in the member and divide the allowable by the actual, so that the condition of the member will be stated as an **"efficiency."** In figuring these stresses, deduct from the section the amount lost by corrosion.

(9) Prepare a suitable **table,** showing for every member and detail of the bridge the efficiency of that member deduced as above.

(10) On the results of this table, and on a judgment as to the condition of the bridge, a **report** may be based concerning its stability, the amount of strengthening needed to bring it to capacity, and the cost of the same.

Schedule of Material for Electric Installations

The following list of items is intended to serve as a "reminder schedule" for the design of an electrical installation for an average industrial plant. Specifications, etc., for individual items are given elsewhere in this volume.

Direct Current Installation

Prime Mover.—Automatic High Speed Engine.
High Speed Corliss or Four-valve.
Drop Cut-off Corliss.

Steam Turbine.
Gas Engine.
Above may be direct connected or belted. Accessories such as steam and exhaust piping, etc., (which are strictly a part of the mechanical equipment) will not be taken up here.

Belted Generator.—Generator, driving belt, field rheostat, slide-rails or sub-base, pulley, foundation bolts, foundation and erection drawings.

Direct Connected Generator.—Generator; field rheostat; interchange of shaft-gauges, templets and drawings between engine and generator manufacturers; shipment of engine-shaft to generator manufacturer for pressing on armature; outboard bearing, foundation bolts and sub-base (if any) by engine builder; liners and holding-down bolts by generator manufacturer; if no sub-base is used order foundation cap-plates and bolts from generator manufacturer. Foundation and erection drawings.

Switchboard.—Shipment of generator rheostat by generator manufacturer to switchboard builder for mounting, or send drilling-templet only. Lugs on switchboard for connection to external circuits, by switchboard builder. Order main, equalizer and field cables connecting generator to switchboard; if underground, to be encased in lead or in conduit or other type of duct; if overhead, of open or conduit wiring. Wood or channel sill for board. Adjustable braces to wall from top of board. Diagram locating switchboard and cable-trenches to generators, and for main feeders, to be sent to plant.

Wiring. Open Wiring.—Slow burning weather proof or rubber-covered wire; cleats; knobs; screws for latter; beam-clamps, etc., or wood for running boards; main switches and main and branch cutouts, or panel boards and cabinets; rosettes, fixtures, lamp cord, fixture cord, cord adjusters; sockets, shade-holders, shades, lamp guards, arc and incandescent lamps, switches.

Conduit Wiring.—Rubber-covered double-braid duplex wire, sizes No. 8 and larger to be stranded, rigid or flexible conduit, condulets or conduit boxes, junction and pull boxes, panel boards and steel cabinets, switch and outlet boxes, switches, fixtures, arc and incandescent lamps, vapor-proof globes and fittings, pipe-cutting and threading tools, general tools and supplies.

All material used to be "approved" by the National Board of Fire Underwriters and installed according to their rules.

If Wiring is installed under contract make final payment contingent upon receipt of certificate of the local inspection department.

Motors. Belted.—With sub-base and belt-tightening screws, pulley, starting-box, lag-screws or holding-down bolts, wood or channel skids for supporting, foundation for large motors, driving belts, controller for variable-speed motor.

Direct-connected.—Sub-base furnished with driven apparatus (pump, etc.), flexible coupling, pinion for gear or silent-chain drive, gear-case, holding-down bolts and taper pin, outline drawing of motor to builder of driven apparatus. Starting box, controller for variable-speed motor.

Back-geared motors may fall under either of above sub-headings, and additional material will consist of back-geared parts with or without gear case.

Miscellaneous.—Lightning arresters, burglar alarm system, watchman's clock system, telephone systems, bells, buzzers and annunciators.

Numerous special application of electricity, as for theaters, electro-chemical industries, etc., require the services of a specialist and will therefore be of no interest in this connection.

Alternating Current Installation

Prime Mover.—See direct current installation.

For operation of alternators in parallel, a special heavy flywheel and close governing are required.

Belted and Direct-connected Generators.—See direct current installation.

Exciter for alternator to be a direct current "flat" compounded machine, usually 125 volt.

Exciter drive may be direct connected to an independent engine or motor, belted from extension of generator shaft, or, in the case of turbo units, direct-connected to main shaft of unit.

Matter relating to belted and direct-connected, direct current generators also applies to exciters.

Switchboard.—See direct current installation under this heading. Note that equalizer cable will be required only when two or more exciters are used connected to the same set of buses. If current is bought from outside, install suitable wattmeter.

Wiring.—See direct current installation. Also; balance coils for operating (*e.g.*) 110 v. lamps from 220 v. circuits.

Motors.—See direct current installation. Note that for induction motors, an oil immersed auto-starter or starting compensator is used instead of a starting or resistance box.

Miscellaneous.—See direct current installation.

Transformers.—Required for distant transmission, such as remote town lighting, pumping-plants, etc.

SEC. II. CHECKING ENGINEERING DRAWINGS

Engineer's Drawings in General

Following is a list of general considerations which may be gone over by the Chief Draftsman or Designing Engineer before allowing a drawing to be traced; or by the Chief Engineer before affixing his signature of final approval.

A set of engineer's design drawings should be:

(1) **Correct,** as regards
- (a) Owner's wants.
- (b) Good Construction.
- (c) Future Requirements.
- (d) Financial Considerations.
- (e) Principal Dimensions.
- (f) Details.

(2) **Complete,** as regards
- (a) Owner's wants.
- (b) Contractor's Requirements.
- (c) Principal Dimensions.
- (d) Principal Views.
- (e) Details.

Checking Engineer's Machinery Drawings (General)

Following is a list of points, arranged in logical order, which should be gone over by the checker on mechanical drawings: it will, of course,

be necessary for him to consider special points of design in addition to these. The list should also be used by the draftsman after the completion of the pencil drawing and before tracing is commenced.

(1) Correct placing of views.
(2) Titles.
(3) Simplicity for pattern and foundry work.
(4) Design so as to allow use of standard patterns.
(5) Disposition of metal in castings so as to avoid cracking.
(6) Design castings, etc., to obviate breakage in shipment.
(7) Design for mule-back or other special transportation (canoe, tunnel, etc.).
(8) See that pieces to go inside others will go through opening provided.
(9) Material.
(10) Principal dimensions.
(11) Thickness of metal.
(12) Size of shafts, pulleys, etc.
(13) Size of gears, pitch, face, etc.
(14) Size of bolts, rivets, pins, etc.
(15) Speeds of shafts, etc.
(16) Travels.
(17) Interferences.
(18) Detail dimensions.
(19) Finishing marks.
(20) Completeness.
(21) Number of items required.
(22) Marks.
(23) General Notes.

Checking Anchor-bolt Plan for Building

(1) Look over for **general arrangement,** correct placing of sections, size of sheet, etc.; see if plan won't have to be done all over again.

(2) Check **over-all dimensions** and column-centers with Architect's Basement Plan.

(3) Check **Columns** for
  (a) Location and column number.
  (b) Section.
  (c) Turned right direction.
  (d) Completeness.
  (e) Elevation.
  (f) Area of steel base-plate to take load.

(4) Check **Cast Iron Bases** for
  (a) Turned right direction.
  (b) Completeness.
  (c) Elevation.
  (d) Strength and area to take load.
  (e) Anchor-bolt and Grouting Holes.
  (f) Interferences (as per 5h).

(5) Check **Grillage Beams** for
  (a) Strength, etc.
  (b) Turned right direction to suit base, and to be within building-line.

(c) Correct section, and length.
(d) Location, and spacing.
(e) Marks.
(f) Distance apart to allow concreting.
(g) Elevation.
(h) Anchor-bolt holes in correct location.
(i) Interferences with other steel, sumps, elevator-pits, boiler-settings, etc.;

(6) Check **Anchor-Bolts** for
(a) Correct location in respect to column center-line.
(b) Correct distances in relation to column.
(c) Correct diameter and length.
(d) Correct height above bottom of base-plate, etc.

(7) **Miscellaneous**
(a) See that all bolts, beams, etc., are billed.
(b) Look out for missing dimensions, elevations, sections, marks, etc.
(c) Give Cardinal Points.
(d) General Notes and Titles, check for correctness and completeness.

Checking Structural-steel Floor-framing Plan

(1) Look over for **general arrangement,** correct placing of sections, size of sheet, etc.; see if plan won't have to be done all over again. See par. (7).

(2) Check **over-all dimensions** and column-centers with
(a) Architect's plans.
(b) Foundation plan.

(3) Check **Columns** for
(a) Location and column number.
(b) Section.
(c) Turned right direction.
(d) Completeness.

(4) Check **girders and floor-beams** for
(a) Section and general arrangement.
(b) Location and spacing.
(c) Height.
(d) Completeness.

(5) Look out for required **sections** and correctness of same, spandrel and others.

(6) Look out for **tie-rods**; stair-framing; elevator-framing; compound-beam spacing; shelf-angles on beams, columns, and walls; cardinal points; interferences in beam framing; hangers and struts; unsupported columns; tank supports; skylight curbs; lintels; spandrel-channels to clear flues; pipe-spaces; double-beam girders billed right.

(7) **Detail** whole job **mentally; simplify** and **standardize** details.

(8) **General Notes** and Titles; correctness and completeness.

(9) If **changes** are made in one drawing, see that all other drawings, notes, etc., correspond.

Checking Structural-steel Beam Details

(1) **Overlook generally** for correctness of views and location, and completeness.

(2) **Center and over-all dimensions,** clearances at ends, "checking distances" to center-lines.

(3) **Main-material,** compare with floor-plan, and with order-list for correct section and length.

(4) Check each **Framed End Connection** for
- (a) Strength of connection. (Consult "minimum safe length" table).
- (b) Number of field holes for strength in single-shear, and (if combined with load from an opposite beam) in bearing on web of header.
- (c) Material of connection.
- (d) Coping top and bottom.
- (e) Special size of holes.
- (f) Connection square or sloping.
- (g) Elevation of connection.
- (h) Interferences.

(5) Check each **End Connection to Column** (ordinary) for
- (a) To agree with seat connection as to distance from center, gauge of holes, sizes of holes.
- (b) To agree with web-connection clip on column.
- (c) Give (±) allowable from billed length.
- (d) Clearance for insertion.

(6) **Web-connections** on beam
- (a) Location lengthways.
- (b) Elevation.
- (c) Number of holes; distances apart, and gauge to suit beam framing-in; consult beam detail.
- (d) Size of holes.
- (e) Seat connections, stiffeners, web clips.
- (f) "Beams framing opposite" to use same holes.

(7) For **double-beam Girders**
- (a) Special end connections.
- (b) Distance apart.
- (c) Handholes in end (web or flange) to allow assembling a web-connection, etc.
- (d) Separators, distance apart, bolts, special steel separators for transferring one-sided loads.
- (e) See that girder is billed right.
- (f) Separators to clear beam-connections.

(8) **Miscellaneous**
- (a) Shelf-angles for carrying wood or concrete floor. (See warning on p. 211.)
- (b) Punching top flange, for spiking-strips, etc.
- (c) Inspector's dimensions.
- (d) Punching for tie-rods.
- (e) Punching for knee-braces.

(9) **Interferences**
- (a) Erecting between beams, or columns.

(10) **Billing and marking**
- (a) Correct number.
- (b) Correct size and length.
- (c) Correct mark.

(11) **Notes**
- (a) Size of rivets, exceptions.
- (b) Size of open-holes, exceptions.

(c) Painting.
(d) Special marks, shipping, etc.
(e) Contract and Sheet No.
(f) Date and initials.

Checking Structural-steel Column Details

(1) **Overlook generally** for showing faces in right positions; completeness and correctness of views and sections.
(2) **Shipping requirements**; length to get on a single car; big projections to be avoided; for *export work*, detail so as to reduce dimensions to a minimum. (See p. 388.)
(3) Check for **reduction of templet work.**
(4) Check for **reduction of expensive shop work**; one size of rivet only in large pieces; possibility of riveting brackets on box columns, etc.
(5) Check for **reduction of erection expense.**
(6) Check **floor heights,** and relation of column ends to floor heights.
(7) **Milled length,** compare with "ordered."
(8) **Main material,** check against column schedule and order list.
(9) **Connection of base:** top splice; cap plate; direction column is turned; "draw" in splice plate holes.
(10) **Beam Connections:** elevation, size, strength of connection, interferences, rivets countersunk or flattened, connection-hole location and size, top clip loose, strength of eccentric connection.
(11) **Miscellaneous:** knee-brace connections; siding connections; punching for spiking-strips; bracing connections; connections nearly symmetrical not to be reversible; inspector's dimensions (end to seats).
(12) **Rivet-spacing:** closeness at ends and under loads, add and compare with total length.
(13) **Billing and Marking:** correct number of columns, size and lengths and marks. All material billed?
(14) **Notes.**—Size of rivets, exceptions; size of open-holes, exceptions; painting; special marks; special shipping instructions; similarity of templates on other drawings; contract and sheet number; date and initials.

Checking Structural-steel Roof-truss Details

(1) **Overlook generally** for sufficiency of views and notation to cover the various trusses possible to show on one drawing.
(2) Check for **suitability for shipment**; whether sections as shipped will come within clearance limits of R.R.; work for export to be entirely knocked-down.
(3) Check for **reduction of templet work.**
(4) Check for **reduction of expensive shop work**; one size of rivet only in large pieces; angles cut square; gusset-plates with few cuts and detailed to multiple (Fig. 51), etc.
(5) Check for **reduction of erection expense.**
(6) Check **main dimensions**; span; elevation of under-side of lower chord; slope of top-chord; depth of truss as affected by detail at heel; panel spacing; monitor width and height, etc.
(7) **Main material,** compare with design and with order list (for section and length).
(8) **Rivet (center) lines** to be arranged to reduce eccentricity at joint for important connections, to reduce size of gussets for light connections, to be tied-up throughout.

(9) **Riveted joints** to develop stresses given on stress-sheet in shear and in bearing (for thin gussets); add for eccentricity if present on important joints; angles in tension to have both legs engaged for over four-rivet connection.

(10) **Other Details.**—Purlin-clips to have two-hole connection for each end; lower-lateral, top-lateral, sway-brace, and tie-rod connections; punching top-cord and monitor-mullion for spiking-strips; attachment of beams, etc , to L. C ; connections nearly symmetrical not to be reversible.

(11) **Billing and Marking.**—Correct number required, and marks; exception notes; all material billed?

(12) **Notes.**—Size of rivets, exceptions; size of open-holes, exceptions; painting; special marks; similarity of templates on other drawings; contract and sheet No.; date and initials.

Checking R. R. Plate-girder Bridge Details

(1) **Overlook generally** for correctness of views and notation, and completeness of views; see if drawing may not have to be made all over again; consult information-sheet and see that special requirements have been met.

(2) Check for **suitability for shipment**; maximum dimensions and weights allowable; location of field-splices; special features on export work; field splices to be flush; avoid projecting gussets, etc. (See pp. 344 and 388.)

(3) Check for **reduction of templet work** as affected by web, flange and cover-plate river-spacing, etc.

(4) Check for **reduction of expensive shop work**; one size of rivets only; proper rivet gauge; omission of bevel cuts on angles and plates; etc.

(5) Check for **reduction of erection expense**; direction-marks on ends; clearance for swinging floor-beams or cross-frames, etc. Double-check all field-connections.

(6) Check **center and over-all dimensions,** locations of floor-beams, clearances at abutments; missing dimensions; camber.

(7) Check the detail against the **clearance diagram** (from *top* of rail); variation for curvature; height of *base* of rail from masonry and corresponding dimensions of floor-beams and stringers.

(8) **Main material,** compare with design and with order list (for section and length).

(9) **Clearances and Interferences.**—For swinging floor-beams into place on through bridges, and cross-frames on deck bridges; lateral-connections to clear flange splices; lat. plates to enter easily between floor-beam and flange; c'sink base-plate rivets to clear pedestals; anchor-bolt holes to clear end stiffeners; bracing to clear masonry.

(10) **End-connections** and those of other members framing in, check for strength and interference.

(11) **Stiffeners.**—Section; spacing; fitting top and bottom; crimped or filled; end-stiffeners' strength as column and in bearing.

(12) **Rivet spacing.**—In flanges; at ends of cover-plates; in intermediate stiffeners; in end stiffeners; in web splices; gauge on stiffeners to make all floor-beams alike.

(13) **Field Splices.**—Net area of flange-splicing material; number of rivets; proper arrangement of rivets in web-splice.

(14) **Floor-beams.**—Main dimensions, material, interferences, etc., as above; strength of stringer connection (especially in bearing); slot for stringer tie-plate; erection seat; strength of connection of end gusset-plate for moment and shear; connection of lateral plates.

(15) **Stringers.**—Main dimensions, material, interferences, etc., as above; end clearance; ends to be milled; thickness of end angles (to be milled); lateral-bracing connections.

(16) **Lateral Bracing.**—Main dimensions; material; end-connections to develop stress or section; end-strut detail; notching of lat. plates; allowance for "draw" when riveting-up.

(17) **Miscellaneous.**—Planing base-plates (straight or taper); name-plate; size and length of anchor-bolts; anchor-bolt holes to be of size and location to allow drilling holes in masonry after bridge is set; connections nearly symmetrical not to be reversible.

(18) **Billing and Marking.**—Correct number required and marks; exception notes; all material billed?

(19) **Notes.**—Size of rivets, exceptions; size of open-holes, exceptions; reaming; painting; direction marks; special marks; shipping instructions; approximate weight of heavier pieces; similarity of templets on other drawings; contract and sheet number; date and initials.

SEC. III. ENGINEERING DESIGN—MISCELLANEOUS

Engineering Office Aphorisms

(1) Draw everything that is positively known Corollary.—Put down what you know, and work for what you don't know.
(2) Work from the inside to the outside.
(3) Keep dimensions in even figures if possible; avoid small fractions.
(4) Bad luck is the result of poor planning.
(5) Plan your work, then work your plan.
(6) If you have five minutes in which to complete a job, spend three minutes planning how to do it.
(7) Too much time is often spent on little things, and too little time spent on big things.

Classification of Causes of Failures of Engineering Structures

Extract from an article "Historic Failures of Engineering Structures" by Horace R. Thayer, published in Vol. 29, Proc. of The Engineer's Society of Western Pennsylvania. (The subject matter of this chapter deals more particularly with the third class of defects.)

There is a tendency to condemn everything in connection with a job which has failed. While effort should be made to discover other errors, we should keep our minds steadily on the main causes.

The defects of engineering direction may be classified as follows.

(1) Ignorance.
(2) Economy.
(3) Lapses.
(4) Unusual occurrences.

These defects will now be treated somewhat fully.

(1) **Ignorance**

(a) **Employment of Incompetent Men in Charge of Design and Erection.**—Fortunately, the need of experienced employes in these branches of engineering is now fully conceded.

(b) **Supervision and Maintenance by Men without Necessary Intelligence.**—The duties of an engineer do not end with construction, and this fact is

being appreciated more and more every day. We shall not dwell upon the evident desirability of his handling a plant with every detail of which he is familiar, although his services are greatly needed for inspection and repairs.

(c) **The Assumption of Vital Responsibility by Untrained Executives in Charge of Engineers.**—The broad functions of management and the raising and disbursing of funds require an official for this position, but he should not interfere with the function of the designer and constructor unless he is thoroughly competent. It should be noted that the law relieves the subordinates from responsibility if his work is in any way dictated or revised. It is not an infrequent case where a client attempts to meddle in an unwarranted manner with engineering matters. This is a situation which requires great tact. However, it should never be permitted, for it is a very prolific cause of failure.

(d) **Competition without Supervision.**—A low bid on a bridge or building, without specific details, may result in the elimination of waste material and labor, or it may result in a very small margin of profit. It is more probable however, that such a bid represents light loads, high allowable unit stresses, thin material, etc. If an engineer compels too low a bid, he should not put the blame onto the contractor. Usually a bridge of this kind stands up, but it is not durable nor has it the factor of safety against unusual or increased loads. It is remarkable that there have been so few disastrous failures of the class.

(e) **Lack of Precedents.**—This applies where the problem is so new that the information for an accurate solution is not available. Such was the main reason for the failure of the Quebec bridge. In this case the pressure for economy was also present and the executive control was not wisely planned. There are still insufficient data on the strength of large compression members and the methods of latticing them.

(2) **Economy**

(a) **Economy in First Cost.**—In a large percentage of the work undertaken, there is more or less pressure to keep down the cost, to save a dollar here, or to cut out a pound there. The ideal engineer keeps as close to the limit as practicable without getting into actual danger.

(b) **Economy in Maintenance.**—The same questions in another form occur after the structure has been used for several years, when there is corrosion and deterioration or when the loads become heavier. At just what point shall it be said that the structure is dangerous and is therefore unfit for service? Perhaps the necessary funds are difficult or impossible to obtain, perhaps voters or directors refuse to appropriate.

(3) **Lapses**

We have termed "lapses" those cases where an engineer, in other respects careful and competent, has shown negligence in a certain part of his work. He may have made careful provision for vertical loads, but failed to care for traction, or perhaps for an uplift due to wind. He may have fireproofed his columns and floors, but neglected to protect the roof trusses, which may result in a complete failure of the building.

(4) **Unusual Occurrences**

As such we may mention earthquakes, extreme storms, very high water, derailment or collision on a bridge. A failure due to any of these causes can hardly be called the fault of the engineer. It is evident that it would be impracticable, to say the least, to provide absolute safety of the structure in case of derailment or collision. It would probably cost more money and more lives than would be saved by such provisions. However, an efficient floor system with guard rails and guard timbers will avert considerable loss.

CHAPTER III

SPECIFICATIONS FOR ENGINEERING MATERIAL

Introduction

In an engineering office engaged on industrial work, a large number of contracts for a great variety of material are constantly being placed in a more or less formal manner. The essential features of the principal documents enumerated in Chapter V will still be preserved, but for the sake of economy and convenience will often be included in a letter or two and an accompanying specification (so called). Thus, the "Invitation to Bidders," may be the subject of a letter from the engineers to a number of contractors, the "Instructions to Bidders" and the "Specifications" are best included in one "Specifications," and the "Proposal" and "Contract" may be on the contractor's standard form or may be the subject of a letter from the contractor to the engineers. For example, in the following "Specification Outlines" the "Instructions to Bidders" and the "Specifications" proper have been combined. However, as is elsewhere explained, it is often a matter of opinion as to under which heading a certain clause should be placed; so that, in the following system of specification writing, some headings may be included which the individual specification-writer may choose to take care of elsewhere.

The system has been developed during a number of years of experience in an engineering office handling a large variety of work, and the best recommendation of its satisfactory fulfilment of its purpose may be found in the fact that it has become a very rare occurrence for bidders or contractors to have to request any more information from the engineers while preparing their quotations or fabricating the material. The saving of time in the obtaining of bids, the uniform prices secured, and the saving of time and trouble to the office and field force have compensated many times over for the extra care and time placed on the preparation of the specifications.

When one considers the vast number of specifications turned out, even for important works, that are based on no apparent plan or system whatever, where detail information is enlarged upon under a general heading, where matters of widely different connection are grouped under a single irrelevant heading, and where the whole specification has to be gone over in order to find one desired clause—when one considers the number of such productions turned out by men of technical

ability but of illogical mind—the importance of emphasizing the systematic arrangement of the specification would seem to be emphatic.

The "reminders" embodied in the following "specification outlines" may also be used as the basis for a "specification letter" in case it is not desired to draw up a more formal specification. (See p. 215.)

SEC. I. A SYSTEM OF SPECIFICATION WRITING

Arrangement of the Specification

Heading

The heading will be seen to give the name and address of the engineers, the specification and file number (if any), the date of writing, the contract or estimate number, the title of the specification, and a list of the drawings to which it refers. The name of the clients may also be added (if desired) after the contract or estimate number; it is usually preferred, however, to keep this out.

Then follows a brief clause connecting the drawings, the specifications and the engineers; and making note of any precedence of one over the other, etc.

General Description

This should contain a brief, "long-distance" view of the scope of the work, so that the reader may "orient" and concentrate his mind on the coming proposition. Details that do not influence the character of the work are entirely out of place.

Conditions of Bids

This section should state whether material only is to be delivered, labor supplied or both, and where; for a lump sum, pound-price or other type of contract; when the work is to be completed; when bids are to be submitted and in what form, etc.

* * *

At this point, the specification in its general features is complete—a prospective bidder can decide whether he is interested; and, if he is not, can dismiss the whole matter. What follows is detail, important only to the man whom the foregoing clauses have interested.

* * *

Material to be Supplied (or, Work to be Done)

This section should be detailed and complete, and should be followed by a paragraph specifying any material relating in any way to the job that is *not* to be supplied. Especial care should be taken with this section so that there may be absolutely no question as to the contractor's liability in the matter.

Details of Construction

This section may be as lengthy as desired, and should be properly "sub-headed."

Material

This may consist of a short general clause; or for important work, may be "sub-headed" and developed.

Workmanship

Besides the usual clause as to first-class workmanship (retained as a brief, although unsatisfactory, protection against poor work excused as "trade

custom" and for its "moral" effect), this section should specify any refinements, etc., required.

Inspection and Test

See examples.

Painting

See examples.

Erection Marks

See examples.

Packing and Shipping

This section applies more particularly to export shipments, and should give a definite idea of the extent to which the material should be protected for ocean-shipment. It should also call attention to the fact that the pieces must be suitably marked and numbered, that detailed shipping lists are to be furnished, etc. Where shipping directions are complex or lengthy, it is usually best to merely refer to them, leaving it to the shipping department to see that the proper instructions are issued and complied with.

Drawings to be Furnished

This refers to drawings for approval and to erection drawings; see examples.

*　　　*　　　*

The specification is now supposed to be complete for the one case under discussion, alternate propositions have not been allowed to interfere with the continuity and completeness of the specification. Unless in the nature of a completely different proposition (when they should be the subject of a separate specification) each alternate may now be taken up and disposed of.

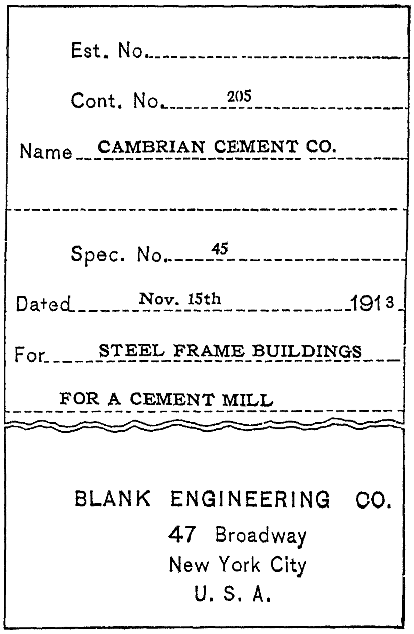

Est. No.
Cont. No. 205
Name CAMBRIAN CEMENT CO.
Spec. No. 45
Dated Nov. 15th 1913
For STEEL FRAME BUILDINGS
FOR A CEMENT MILL
BLANK ENGINEERING CO.
47 Broadway
New York City
U. S. A.

FIG. 24.—Form for specification "Backer."

*　　　*　　　*

Alternate Proposals

Each alternate should be numbered (Alt. No. 1; Alt. No. 2; etc.) and each should be the subject of a separate heading, however nearly alike they may be; it does not cost any more to be liberal with numbers, and always saves confusion.

The alternate proposition will usually be written "as per the above specification; except that, etc."; or the bidder may be requested to submit a proposal according to his own design or recommendation.

SPECIFICATION "BACKERS"

It adds to the appearance and durability of specifications if they are "backed" by a sheet of heavy paper; or a double sheet may be used

so as to constitute a folder. The specification may be given a double fold so as to be readily placed in an envelope, and one of the exposed faces should show a printed form suitably filled in. Such a form is given in Fig. 24.

SEC. II. EXAMPLES OF SPECIFICATIONS

(1) Specification for a Molasses Storage Tank

The specification given below was for material for a molasses tank to be exported to Cuba. The drawing accompanying it was a complete design, giving thickness of all plates, required rivet-spacing and lap, etc., but was not a detail drawing. It will be noted that an alternate quotation is requested in a different manner than the schedule calls for; the simplicity of the alternate seemed to warrant the departure from the standard method.

The required time of delivery may be left blank when inquiring for prices, the bidders being requested (in the letter of invitation) to state how soon they could make delivery; the time can then be inserted in the specification of record, when placing the order.

Spec. No. 1. Feb. 27, 1913.

BLANK ENGINEERING COMPANY

NEW YORK CITY

CONTRACT NO. 176

Specifications for a 1,000,000–gallon Waste Molasses Tank

Card No. 2442

These specifications refer to the above drawing of the Blank Engineering Co., and are intended to cooperate with same.

General Description

A Cylindrical Tank, 75 ft. 0 in. diam. × 32 ft. 0 in., high, made of steel plates and angles with a cover of steel plate, and provided with pipe connections, manhole, ladder, tell-tale, etc.

The cover shown on the drawing consists of a self-supporting dome; the contractor, however, may substitute a cover of No. 10 steel plate on a trussed frame (with or without central pipe-column), or any other cover of equivalent strength and durability that may be approved by the B. E. Co.

Also the thickness of plate and efficiencies of joints given for the belt courses may be altered by the contractor if desired, the requisite strength being provided for the pressure due to liquid at 88 lb. per cubic foot, and a working stress on the plate of 14,000 lb. per square inch of net section.

Conditions of Bids

Bids are to be for a lump sum for the material complete delivered f.a.s. New York Harbor, not later than (—) weeks from date of order.

The estimated shipping weight must be stated in the bid.

Bids are to be submitted in duplicate.

If any other construction than that shown is proposed by the bidder, drawings and descriptions completely illustrating the same must be furnished with the bid.

Material to be Supplied

The material to be supplied by this contractor will consist of the material complete for constructing one (1) tank as shown on the drawing, including rivets for making all connections with an excess of 10 percent, and a liberal quantity of setting-up bolts.

Material

All plate is to be of the best "Tank" steel, full to gauge and free from flaws, structural steel to be open-hearth medium steel 60/70,000 lb. per inch ultimate strength; castings to be of a good quality of gray iron, true and free from imperfections of any kind.

Workmanship

To be first-class in every respect Joints are to be scarfed wherever necessary and rivets spaced close enough to allow all seams to be caulked water-tight. All flanges of pipe-fittings, etc., are to be faced and drilled to make a complete job.

Marking

All parts of this tank are to bear marks corresponding to those of an erection drawing. These marks are to be made with white paint and also with steel stamping dies. Marks on plates are to be made on *both sides*, so that a plate will not have to be turned over to ascertain its marks.

Shop Painting

The plates, after marking, are to be given one coat of boiled linseed oil all over. All other material is to be given a coat of *yellow* paint.

Inspection

This material will be subject to inspection at any time by a representative of the Blank Engineering Co. Any material found defective, or *not properly marked*, will be liable to rejection.

Packing

The tank is to be knocked-down for export, but as much of the riveting and shop work as possible is to be done before leaving the works. Small pieces are to be boxed and wired for ocean shipment, boxes numbered and contents given on shipping list.

Drawings Furnished

As early as possible after receipt of order the contractor will forward to the engineers, two complete sets of shop detail drawings for approval, one of these sets when approved will be returned signed to the contractor and the other will be retained by the engineer for his file; any work not in accordance with the approved drawings may be subject to rejection.

The contractor shall be responsible for dimensions and details in working plans, and the approval of the detail plans by the engineer shall not relieve the contractor of this responsibility.

Also at time of shipment of material, this contractor shall forward to the engineers, two complete sets of erection drawings on cloth and two sets on paper and any further sets reasonably required.

(2) Specification for a Belt Conveyor

The specification given below was for material to be exported to Mexico. The accompanying drawing was in the nature of a preliminary design, the principal dimensions were given, but the detail construction depended upon the material offered by the contractor. A slat conveyor was finally adopted, and the gallery, etc., was designed after the receipt from the contractor of his detail and arrangement drawings.

Spec. No. 2. Oct. 30, 1911.

BLANK ENGINEERING CO.

NEW YORK CITY

CONTRACT NO. 151

Specification for a Belt Conveyor from Alcohol Warehouse to Wharf

Drawing No. 2084

These specifications refer to the above drawing of the Blank Engineering Co., and are intended to cooperate with same.

Description and Service

A belt conveyor 144 ft. 0 in. long. c. to c. of end pulleys, for conveying cases of alcohol from the platform of a warehouse to a delivering staging on a river bank.

Material to be Conveyed.—Cases, made of light wood 20 in. × 10 1/2 in. × 15 in. high, containing two canisters of alcohol, and weighing 77 lb. per case.

Capacity.—1,000 cases per hour.

Drive.—By engine or motor, see drawing for arrangement.

General.—The general arrangement of the conveyor is shown on the drawing which may be scaled for dimensions not given.

Condition of Bids

Bids are to be for a lump sum for the material delivered complete f.a.s. New York Harbor not later than (—) weeks from date of order.

Bids must state estimated shipping weight of the material.

Bids are to be accompanied by a detailed specification with sketches, describing the material proposed to be furnished, and giving speed of belt, horse-power required to operate, etc.

Material to be Supplied

The material to be supplied by this contractor will consist of the special material of the installation complete, including main belt; rollers; carriers with grease cups, etc.; head or driving end complete with main pulley, reduction-gearing, driven pulley, boxes, etc.; tail end complete with take-up; and all bolts and fastenings required to completely erect the above with 10–20 percent excess.

This contractor will *not* supply any part of the gallery framing or covering, nor the loading or unloading platforms, nor the movable chute at discharge end, nor the engine or countershaft, nor any driving belts or chains.

Marking

Every piece of this work is to be distinctly marked with an erection mark corresponding to that on erection drawing, so that there may be no question about its location in the structure.

Also shipping marks are to be given as per instructions in the formal order.

Inspection

This material shall be subject to inspection at any time by a representative of the Blank Engineering Co.

Packing and Shipping

All material is to be knocked down for ocean shipment, small pieces to be boxed and wired, boxes numbered and contents given in shipping list.

Drawings Furnished

Within 2 weeks of date of order, this contractor is to forward to the engineers two sets of drawings showing the arrangement and detail of his machinery, so that drawings for the gallery may be made by the engineers.

Also at time of shipment of materials, this contractor shall forward to the engineers one copy on cloth and two copies on paper of an erection drawing for his material.

Alternate Quotations

(1) Bidders are requested to propose and to submit bids on any other type of conveyor that they may consider better suited for accomplishing the operation outlined above.

(2) Bidders are requested to submit the addition in prices for the conveyor in case the same is lengthened to 200 ft. 0 in. and 250 ft. 0 in. respectively.

(3) Specifications for Steel Mill Buildings

The specifications given in full below were for material for a large steel frame factory building for export.

The drawings submitted with the specification gave all principal dimensions, weights of all machinery, floor loads, spacing of beams under machinery, location and size of all windows and doors, etc., but did not give any sizes of shapes unless they were of specially required section. The contractor was therefore at liberty to use his favorite or most economical shapes and details. The drawings were sufficiently complete, so that if stresses and sections were added they constituted true stress-sheets, and the prints submitted to the bidders were, in fact, often so used by them.

In writing specifications for structural-steel mill buildings, it is very important that every item of the construction be definitely fixed. Unless this is done there is liable to be a wide variation in the prices submitted, with the certainty that the lowest bidder has "skinned" the job as much as he dare and as much as the loosely drawn specifications will permit; such specifications work injustice to reputable contractors, and breed trouble for the owner.

Spec. No. 3. Dec. 11, 1912.

BLANK ENGINEERING CO.

NEW YORK CITY

CONTRACT NO. 186

Specifications for Steel Buildings for a Cane Sugar Factory

Drawings Nos. 2073–D, 2386, 2388 and 2389

These specifications refer to the above drawings of the Blank Engineering Co , and are intended to cooperate with same.

General Description

The steel frame factory building covered by these specifications consists of seven connecting rooms or houses, a description of which is as follows:

(1) A Cane Shed, 30 ft. 0 in. wide × 100 ft. 0 in. long c. to c. of columns × 15 ft. 0 in. to L.C., covered as to roof and partly as to sides with corrugated steel.

The sides and one end will be open for a convenient distance from the ground, and no doors, windows or monitor will be required.

(2) A Mill Room, 60 ft. 0 in. wide by 96 ft. 0 in. long c. to c. of columns by 26 ft. 0 in. to L.C., covered as to roof and partly as to sides with corrugated steel; and provided with doors, skylights, windows and monitor as shown. The columns will support a runway for a travelling crane; and, as no knee-braces are permitted, the column anchorages and the lower chord and end bracing must be designed especially to take care of the wind loads on this building One side will be arranged for future extension; see note on drawing.

(3) A Boiler Room, 59 ft. 4 in. wide × 118 ft. 6 in. long c. to c. of columns × 26 ft. 0 in. to L.C., covered as to roof and partly as to sides with corrugated steel, and provided with windows, doors, awning and monitor as shown. Part of the floor will be of R.C. flat slab construction on steel beams. Along part of one side will be an awning placed about 9 ft. 6 in. from the ground One end of the building will be separated from the Mill Room by a corrugated steel partition. The end is to be arranged for extension.

(4) A Clarification House, 80 ft. 0 in. wide × 112 ft. 0 in. long c. to c. of columns × 37 ft. 0 in. to L.C., covered as to roof and partly as to sides with corrugated steel, and provided with windows, doors, skylights and monitor as shown.

There will be floor framing at elevations 12 ft. 0 in. and 26 ft. 0 in. for R.C. flooring, and stairs, railings, tank platforms, elevator-shaft framing, etc., as shown on the various drawings. The evaporator staging is also to be supplied by this contractor.

The building is to be arranged for extensions as shown on the drawings.

One side of the roof will carry a pent-house.

(6) A Lean-to to the Clarification House for an Electric Plant, 20 ft. 0 in. wide × 32 ft. 0 in. long c. to c. of columns × about 14 ft. 0 in. to eaves (at col.), covered as to roof and sides with corrugated steel, and provided with windows and doors as shown It will be entirely partitioned off from the adjoining houses. One end will be arranged for extension.

(6) A Boiling House, 50 ft. 0 in. wide × 88 ft. 0 in. long c. to c. of columns × 64 ft. 0 in. to L.C., covered as to roof and partly as to sides with corrugated steel, and provided with windows, doors and monitor as shown. Where this house adjoins other houses, *no* partition will be provided. There will be floor framing for R.C. flooring at elevations 8 ft. 0 in., 26 ft. 0 in. and 44 ft. 0 in., and

above the latter floor will be tank platforms, etc.; stairs, railings, etc , are to be provided as shown on the various drawings.

One end of this house will consist of a temporary lean-to, which will in future be removed and the house extended on lines similar to the present construction.

(7) A Sugar Room, 34 ft. 0 in. wide × 80 ft. 0 in. long c. to c. of columns × about 32 ft. 6 in. to eaves (at col.), covered as to roof and partly as to sides with corrugated steel, and provided with windows and skylights as shown.

There will be floor framing for R.C. flooring at Elev. 26 ft. 0 in., and a bin platform at Elev. 19 ft. 9 in.

Conditions of Bids

Bids are to be for a lump sum price for the material delivered complete f.a.s. New York Harbor not later than (———) months from date of order.

For alternate proposals desired, see end of this specification.

The proposal shall be accompanied by stress sheets with full information as to calculated stresses and sizes of all material.

Bidders must submit estimated shipping weight of this material with bid.

Work Included

The material to be supplied by this contractor will consist of all necessary structural steel work; columns, posts, roof-trusses, rafters, knee-braces, monitor-framing, mullions, purlins, siding-girts, partition-framing, crane girders with rails, clips and stops, rod and angle bracing, struts, tie-rods, hangers, floor beams and girders, trestles, tank stagings, curbs, elevator-hatch framing, indented (or checkered) plate for platforms, finishing-angles, sag-rods, grillage beams and anchor-bolts, together with field rivets and bolts 10 to 20 percent in excess of number actually required and a liberal quantity of erection bolts.

Also all the "Finishing" work, including corrugated galvanized steel roofing, siding, and partition-enclosing material, gutters, leaders, louvres, wire-net for all louvres and eaves openings, ridge-roll, glass windows, skylights, doors, corner-boards, casing, casing covering, flashing, reinforcing metal for concrete floors, elevator grilles, railings, stairs, and all fastenings required to erect the above are to be supplied.

This contractor will *not* supply any of the machinery, tanks, etc., indicated on the drawings; nor the travelling crane in the Mill Room; nor any base-boards or cornices; nor the passenger elevator or doors for shaft.

Loads

Wind.—A horizontal pressure of 40 lb. per square foot, the normal component on the roof to be computed by Hutton's formula.

Concrete Floors.—150 lb. gross per square foot of area covered, except where noted otherwise.

Steel Plate Floors.—100 lb. gross per square foot of area covered.

Wood Floors.—100 lb. gross per square foot of area covered.

Machinery Loads.—See drawings; for F. S. see "General Notes" on drawing.

General.—The buildings are to be designed to withstand in all their parts the maximum combination of dead, live and wind loads given above.

As an alternate loading to the above, the roof-trusses shall be designed to withstand, in addition to the loads given on the drawings, a gross roof load of 30 lb. per square foot of horizontal projection.

The maximum stress in any member produced by either of the above loadings is to be used for designing the member.

Proportion of Parts

Where sizes are not specified on drawings the following unit stresses shall be used to proportion all parts of the structure

7

Steel in tension	15,000 lb. per square inch
Steel in compression	15,000 lb. – 50 l/r (12, 500 lb. Max.)
Shear in shop rivets	12,000 lb. per square inch
Shear in field rivets	10,000 lb. per square inch
Bearing on shop rivets	24,000 lb. per square inch
Bearing on field rivets	20,000 lb. per square inch

For wind stresses the above figures may be increased 66.7 percent. For F. S. for certain machinery loads, see "General Notes" on drawing.

In calculating net area of section, rivet holes are to be assumed 1/8 in. larger than undriven rivet.

Members subject to the action of both axial and bending stresses shall be proportioned so that the greatest fibre stress will not exceed the allowed limits in that member.

No material less than 1/4 in. thick is to be used except for fills, but this clause does not apply to the webs of rolled beams and channels.

For purposes of design, the main framework (columns, trusses, struts and bracing) is to be of sufficient strength and stability to withstand all the loads applied to the structure, *i.e.*, no reliance is to be placed upon siding-girts, etc., to support the framework.

Purlins, girts, etc., are to be figured as beams, not as catenaries.

The maximum allowable values of l/r for compression members will be as follows:

Crane or Machine Columns	100
Heavy Static Columns	125
Shed Columns and Truss Chords	150
Truss Webs	175
Struts	200

But nothing in these specifications shall allow the use of members of lighter or weaker section than those shown on the drawings.

Steel

All steel to be medium steel 55/65,000 lb. per square inch ultimate T.S., made by the Open Hearth Process.

Connection of Beams to Columns

Every beam or girder *in the Boiling House* connecting to a column, shall be connected thereto by a substantial web-connection so as to secure a maximum of rigidity for the fastening; ordinary seat and top-angle connections alone *will not be tolerated* for the Boiling House.

Field Connections

All field connections of purlins, siding-girts, flooring, curbs and crane rails are to be bolted, all other connections to be riveted.

Floor Plates

"Indented" or "Checkered" plates may be used at the option of the contractor, but all must be of the same style of plate.

Typical Details

The typical details given on Drawing No. 2073–D are to be followed substantially as shown, in-so-far as they apply to this building.

Sheet Metal Work

The roof is to be of No. 20 galvanized corrugated steel sheets with side laps of 1 1/2 corrugations and end laps of 6 in. fastened to purlins in the special manner

called for on the drawing, and to each other with 1/4 in. × 1 in. round-head galvanized bolts with lead washers.

The siding and partition covering is to be of No. 24 galvanized corrugated steel put on as described for roofing, but with laps of 1 corrugation and end laps of 4 in.

The ridge-roll, gutters and leaders will be of No. 20 galvanized steel to be fastened to the corrugated steel in a similar manner.

The louvres will be made of No. 20 galvanized steel, and each louvre panel is to be entirely covered on the inside with galvanized steel wire cloth as called for on the drawing.

All flashing and casing-covering will be of No. 24 galvanized steel.

Windows

Supply glazed windows of sizes as, and at location given on drawing; 10 percent excess of glass to be included to allow for breakage, also putty, etc., to make a complete job.

Skylights

The skylights shall be of the size given on the drawing and shall be of the puttyless type, of a design to allow for free expansion and contraction, or movement due to vibration, of the glass and supporting bars, all in the same direction.

The supporting bars shall be of rolled steel and shall be held in a loose manner at the upper end and in a fixed manner at the lower end, by brass clips.

Packing, filling substance of whatever kind, or material other than glass and metal, shall not be used.

All skylights sheet-metal work shall be of copper.

The glass panes are not to exceed 3 ft. 0 in. in length.

The glass shall be 3/8 in. thick ribbed wire glass; supply 20 percent excess to allow for breakage.

It is intended that these skylights shall be of the best construction obtainable, suitable for the service indicated.

Sliding Doors

The small doors are to be made of at least two thicknesses of 7/8-in. dressed and matched sheathing nailed together diagonally and the whole covered with No. 26 galvanized steel. They are to slide on an overhead track which is to be provided complete.

The large doors are to be of similar construction and at least 2 1/2 in. thick. They are to be made in two leaves, sliding on the same track, which is to be covered type placed on the outside.

Each door is to be provided with a substantial lock and key.

Stairs

All stairs are to have channel strings and ribbed plate treads, with checkered or indented plate landings.

Reinforcing Metal

For the floor over the ash pit in Boiler Room, supply steel wire cloth having about 0.15 sq. in. of metal per foot of width in the main section (*i.e* , cross-wire area *not* included).

For the remainder of the concrete floors of the building (see Card No. 2389) supply steel wire cloth having about 0.15 sq. in of metal per foot of width in the main section (*i.e.*, cross-wire areas *not* included). It will be laid on top of beams to form a flat floor slab, and sufficient must be supplied to form a side lap one mesh wide and an end lap one and one-half meshes long.

Wire Net

All ventilating openings are to be protected with a screen of steel wire cloth galvanized, made of No. 19 wire with 3/4-in. mesh stretched on heavy wire frames, these frames to be bolted to the steel work with hook bolts. No net required back of windows.

Workmanship

To be first class in every respect.

Painting

The steel work is to be given one coat in the shop of the Detroit Graphite Co.'s No. 32 "Superior Graphite" paint, or of any other paint to be approved by the engineers.

Marking

Special care is to be taken that erection marks be made in such a manner as not to be obliterated in transit. *Steel stamping dies to be used* in addition to paint marks.

The material will also be given shipping marks as per instructions in the formal order, *in a different color paint* to that used for the erection marks.

Boxing and Packing

All material to be knocked-down for ocean shipment, but as much of the riveting as possible is to be done in the shop. Small pieces boxed and wired, boxes to be numbered and contents given on shipping list.

Inspection

This material will be subject to inspection at any time by a representative of the Blank Engineering Co.

Drawings Furnished

As early as possible the contractor shall forward to the engineers, two complete sets of shop detail drawings for approval, one of these sets when approved will be returned signed to the contractor and the other will be retained by the engineer for his file; any work not in accordance with approved drawings may be subject to rejection.

The contractor shall be responsible for dimensions and details in working plans, and the approval of the detail plans by the engineer shall not relieve the contractor of this responsibility.

Also within 3 weeks of date of order the contractor shall be required to forward to the engineers two complete sets of foundation plans on cloth and two complete sets on paper, giving size and position of grillage-beams and foundation bolts, and at time of shipment of materials two complete sets of erection drawings on cloth and two sets on paper and any further sets reasonably required.

Delivery of Anchor-Bolts and Grillage Beams

Anchor-bolts, washers and grillage-beams must be delivered f.a.s. New York Harbor not later than (—) weeks from date of order.

Alternate Quotations

Bids are also requested for material for the above buildings with construction modified as follows:

Alt. No. 1.—With the floors as shown on Card No. 2389 constructed of steel plate instead of concrete. (Note.—The floor over the Ash Pit in the Boiler Room to remain of concrete.) The flooring is to be of 3/16 in. checkered or

indented plate secured to 3-in. beams or channels, which are, in turn, to rest on and be secured to the main beams or girders of the floor.

The plate is to be bolted to the small beams or channels by means of snap head bolts with very flat heads; countersinking is not required. The small beams or channels are to be spaced not more than 3 ft. 0 in. apart.

The small beams and channels are to be secured to the main floor beams by means of suitable clips or bolts, so that punching of the main floor beams (at least) will not be necessary. Provide 3-in. high angle curbs all around.

For resulting gross floor load see "Loads" above.

Alt. No. 2.—With the floors and platforms as shown on Card No. 2389 constructed of wood, instead of concrete and steel plate. (Note.—The stair platforms and elevator landings to remain of steel plate; and the floor over the Ash Pit to remain of concrete.) The floor beams need not be punched to receive the wood, but nails or clips are to be supplied for attaching the floor to the steel beams. For resulting gross floor load see "Loads" above.

(4) Specification for an Elevated Water Tank

This is given as an example of a specification form which may be used when there are no accompanying drawings. It will be noted that the heading is of a different form, and one that will be found more direct and convenient when no drawings are submitted.

Spec. No. 4. March 6, 1913.

BLANK ENGINEERING CO.

NEW YORK

CONTRACT NO. 176

Specifications for a 100,000-gallon Elevated Water Tank

(No Drawing)

Supply one (1) 100,000 gallon elevated water tank as per these specifications of the Blank Engineering Company.

Description

A water tank of steel plate construction with steel plate cover, having a capacity of 100,000 gallons, carried on a steel staging having a height of 40 ft. 0 in. from base of columns to lowest point of tank.

The general outline of the structure is left to the bidder; utility and economy are the principal considerations, appearance being of secondary interest.

A ladder is to be provided leading to the roof of the tank, where entrance to an interior ladder, leading to the bottom of the tank, is to be effected by a manhole and cover.

A 10-in. W. I. supply and discharge pipe is to be provided, connecting to the bottom of the tank with a flanged connection and at the bottom with a flanged base-elbow. A suitable expansion joint is to be provided in this pipe, but no provision is to be made for insulation. No valve is required.

A suitable tell-tale is to be fitted.

The staging is to be made of structural steel posts and struts, with adjustable tension members.

The entire structure is to be of metal, no wood whatever is to enter into the construction.

Conditions of Bids

Bids are to be for a lump sum for the material delivered complete f.a.s., New York Harbor, not later than (—) weeks from date of order.

The estimated shipping weight must be stated in the bid.

Bids are to be accompanied by stress sheets giving calculated stresses and sizes of all material, construction and efficiencies of joints, etc.

Bids are to be submitted in duplicate.

Material to be Supplied

The material to be supplied by this contractor will consist of the tank complete with staging, cover, ladder inside and out, tell-tale, discharge piping complete with base-elbow and expansion-joint, manhole, foundation bolts; all rivets and bolts in 10 percent excess necessary to erect the above, and a liberal quantity of fitting-up bolts.

This contractor will *not* supply any valve.

Loads

Live Load.—In calculating stresses, the water is to be figured at 62 1/2 lb. per cubic foot. *No* snow load.

Wind Load.—Forty pound per square foot of horizontal surface, reduced 50 percent for cylindrical surface.

Total Load.—The structures are to be designed for the maximum combination of dead, live and wind loads.

Proportion of Parts

The steel plates of the tanks are to be figured at a safe T.S. of not more than 12,500 lb. per square inch of net section.

For the staging the following unit stresses are to be used:

Steel in tension	15,000 lb. per square inch
Steel in compression	15,000 lb.–50 l/r (12,500 lb. max.)
Shear in shop rivets	12,000 lb. per square inch
Shear in field rivets	10,000 lb. per square inch
Bearing on shop rivets	24,000 lb. per square inch
Bearing on field rivets	20,000 lb. per square inch

For wind stresses the above figures may be increased 66.7 percent.

In calculating net area of sections, rivet holes are to be assumed 1/8-in. larger than undriven rivet.

For the tank plates, no material less than 1/4 in. thick is to be used; but the cover may be of thinner plates.

For the staging, no material less than 1/4 in. thick is to be used except for fills; but this clause does not apply to the webs of rolled beams and channels.

The maximum allowable values of l/r for compression members will be as follows:

Posts	150
Struts	200

Material

All plate is to be of the best "Tank" steel, full to gauge and free from flaws; structural steel to be open-hearth medium steel 55/65,000 lb. per inch ultimate strength, castings to be of a good quality of gray iron, true and free from imperfections of any kind. All material to be the best of its respective kind, suitable to the use intended.

Workmanship

To be first-class in every respect. Joints are to be scarfed wherever necessary and rivets spaced close enough to allow all seams to be caulked water-tight

Marking

All material is to be marked to correspond with an erection drawing. These marks are to be put on both sides of plates so as to obviate the trouble of turning over the plates to find the mark. The marks are to consist of a numeral preceded by the letter mark "WT." Also shipping marks are to be given as called for in formal order and in a *different colored* paint to that used in the erection marks.

Inspection

This material will be subject to inspection at any time by a representative of the B. E. Co. Any material found defective, or *not properly marked*, will be liable to rejection.

Shop Painting

All sheet metal work will be given one coat of boiled linseed oil in the shop.
Other material is to be given a coat of *green* colored paint.
Bright surfaces will be covered with an anti-rust.

Packing and Shipping

This material will be knocked-down for export shipment, but as much of the riveting and shop work as possible is to be done before leaving the works.
All parts must be suitably supported or crated for export shipment, small pieces to be boxed and wired, boxes numbered and contents given in shipping list.

Drawings Furnished

As early as possible the contractor shall forward to the engineers, two complete sets of shop detail drawings for approval, one of these sets when approved will be returned signed to the contractor and the other will be retained by the engineer for his file; any work not in accordance with approved drawings may be subject to rejection.
The contractor shall be responsible for dimensions and details in working plans, and the approval of the detail plans by the engineer shall not relieve the contractor of this responsibility.
Also at time of shipment of materials the contractor shall forward to the engineers two complete sets of erection drawings on cloth and two sets on paper and any further sets reasonably required.

SEC. III. OUTLINES FOR MISCELLANEOUS SPECIFICATIONS

Outline of Specification for a Steel Mill Bldg.

(Intended to accompany complete general arrangement drawings, giving principal dimensions, loads, special beam-spacing, etc., but not giving strains or sections except for special conditions. For an example of a specification for a group of buildings see p. 95. The following outline calls for prices both f.o.b. and erected.)

Heading as per example p. 96.

Drawings No. ———, ——— and ———

"These specifications refer to the above drawings of the (———) Engineer Co., and are intended to cooperate with same."

General Description

Principal dimensions of building, mention of floors, crane-runways, stairs, monitors, ventilators, roofing, sides, windows, doors, etc , in a brief, descriptive manner. Also mention any special conditions of the design that may need to be emphasized.

Conditions of Bids

"Bids are requested as follows:"

Proposal 1.—To be for a lump sum for the material f.o.b./f.a.s. (place), not later than (———) months from date of order.

Proposal 2.—To be for a lump sum/pound-price for the material erected at (———) not later than (———) months from date of order

Proposal to be accompanied by a stress sheet: estimated shipping weight to be stated: bids and stress sheets to be submitted in duplicate.

Material to be Supplied

To consist of all necessary structural steel work, columns, posts, trusses, rafters, knee-braces, monitor-framing, mullions, purlins, girts, crane girders with rails, clips and stops, shafting-supports, floor beams and girders, partition-framing, door-sills, rod and angle bracing, struts, tie-rods, hangers, trestles, stagings, elevator-hatch framing, steel plate flooring, curbs, wall plates, wall anchors, lintels, expanded metal or other reinforcement, finishing angles, sag-rods, grillage-beams and anchor bolts, field rivets and bolts in 10 percent to 20 percent excess, erection bolts.

Also all the "Finishing Work," including corrugated galvanized steel roofing, siding and partition covering, gutters and leaders, ridge-roll, cornice, glass windows, window shutters, doors, skylights, window gratings, wire net, ventilators, louvres, door-guards, leader-boots, corner-boards, base-boards, casing, eaves flashing, casing covering, stack flashing and hood, and all fastenings required to erect the above.

Loads

Wind horizontal, component formula for roof; vertical roof load (as alternate to the preceding), maximum stress to be used; the above to be in addition to loads given on drawings (Note: it is usually better to give floor, crane, and concentrated loads on the drawings).

Initial stresses in bracing rods.

Provision for earthquake stresses.

Proportion of Parts

Where sizes are not specified on drawings, the following unit stresses to be used: steel in tension, in compression, shear in shop rivets, in field rivets, bearing on shop rivets, on field rivets.

Allowable percent increase in above for wind stresses; decrease for electric crane (vertical) stresses, or for other moving loads.

Minimum thickness of metal (steel), exception in case of webs of rolled beams or channels.

Purlins and girts to be figured as beams, *not* as catenaries.

Maximum allowable l/r for different conditions of struts and columns.

Main frame to be designed to withstand all loads without aid from purlins, girts, etc.

Nothing in the above to allow the use of members of lighter or weaker section than shown on drawings.

Steel

T. S., quality, etc. (briefly).

Field Connections

Specify what parts are to be riveted and what bolted.

Typical Details

Details to be as per typical detail sheet submitted.

Special Details

Describe any special requirements, such as punching of beams, purlins or siding for wood connection or for fire-proofing attachment.

Sheet Metal Work

Roof.—Material, thickness, lap, method of attachment.
Partitions.—Material, thickness, lap, method of attachment.
Louvres.—Type, material and thickness of metal.
Ventilators.—Type, size, material and thickness of metal.
Smoke-stack Hoods.—Material, thickness of metal, method of attachment.
Gutters.—(Sizes on drawing.) Material and thickness of metal.
Leaders.—(Sizes and location on drawing.) Material and thickness of metal.
Miscellaneous.—Material and thickness of metal for ridge-roll, cornice, flashing, casing-covering.

Doors

(Sizes on drawing.) Describe construction. Locks and keys to be provided.

Windows

(Sizes on drawing.) Describe construction.
Excess glass to be supplied, and putty, etc., to make complete job.

Skylights

(Sizes on drawing.) Describe construction.
Excess glass to be provided (to allow for breakage).

Stairs

(Dimensions on drawings.) Describe construction.

Reinforcing Metal

(Portions of floors to be covered shown on drawing.) Type of material required; sectional area per (stressed) lineal foot (or give gauge, mesh and weight per square foot); excess for laps; clips, etc., for attaching.

Workmanship

"To be first-class in every respect."

Painting

Steel work to be painted in shop with (one) coat of (———) paint, parts inaccessible after erection two coats. Field painting (by owners).

Marking

So that marks will not be obliterated in transit; steel stamping dies to be used in addition to paint marks; shipping marks (as per instructions) to be given in addition to erection marks; shipping and erection marks to be in different colors.

Packing and Boxing

(All material to be knocked down for export shipment); small pieces boxed and wired, boxes numbered and contents given in packing list.

Inspection

At any time by representative of the (———) Engineering Co.

Drawings Furnished

Shop detail drawings to be submitted in duplicate for approval, one set to be returned and other retained by engineers; work not in accordance with approved drawings liable to rejection; contractor to be liable for dimensions and details even on approved plans.

Anchor-bolt plans to be supplied within (———) days of date of order

Erection drawings to be supplied at time of shipment of material.

Delivery of Anchor-bolts

Grillage-beams and anchor-bolts to be delivered (———) not later than (———) weeks from date of order.

Alternate Quotations

As requested by engineers or as contractor may desire.

Outline of Specification for a Return-tubular Boiler

(Intended to accompany fully designed drawings: for inquiry reminders for a standard boiler, see p. 134.)

Heading as per examples, p. 92, etc.

Drawings No. (——) and (——)

"These specifications refer to the above drawings of the (——) Engineering Co., and are intended to cooperate with same."

Type and General Dimensions

Of the horizontal, return-tubular, externally fired type, about (————) diameter × (————) long; steam-drum or dome; type of suspension; smoke-uptake (if any).

Working Pressure

Boiler to be designed to withstand a working pressure of (———) pound per square inch.

Conditions of Bids

To be for lump-sum, for material f.o.b./f.a.s./erected at (———), not later than (———) weeks from date of order. Estimated shipping weight to be given. Bids to be submitted in duplicate.

Material to be Supplied

Number of complete units required.

Shell.—To be supplied completely riveted up, with tubes, braces, stay-rods, suspension lugs, manholes, handholes, nozzles, bushings, fusible-plug, feed-pipe bushing, studs for smoke-uptake connection.

Steam-drum.—To be completely riveted up with all nozzles riveted on; pipes connecting to shell to be fitted to drum.

Smoke-uptake.—As shown on drawing.

Other Fittings.—Internal feed-pipe, safety-valve fitting, safety-valves, water column complete, steam-gauge, hangers, beams, saddle-castings, wall plates.

Material not to be Supplied.—Enumerate such of above as are not to be supplied by this contractor.

Quality of Materials

Plate.—To be full to gauge as called for on drawing.

Cyclindrical plates of main shell to be of O. H. Fire Box Steel; heads of shell and steam-drum and barrel of drum to be of O. H. Flange Steel; all as per Manufacturers' Standard or A. S. T. M. specifications.

Brands to be located so as to be visible after boiler is finished.

Certified copies of tests to be sent to the engineers; tests to be at expense of contractor.

Tubes.—To be made of (————), not less than standard thickness.

Braces.—Crowfoot braces to be weldless, made of (———); stay rods.

Rivets.—To be made of (———), as per above specifications.

Smoke-uptake Material.—For plates, angles, etc.

Other Parts.—To be made of material called for on drawing, and "to be the best of their respective kinds suitable to the use intended."

Workmanship

Plates.—Arrangement of plates and seams to be as shown on drawing, plates to be planned on caulking edges before rolling.

Riveting.—To be of sizes and with pitch and lap as called for on drawing. Rivet-holes to be drilled in place (or sub-punched and reamed) plates disconnected and burrs removed. Drift pins not to be used. Rivets to be driven by hydraulic pressure wherever possible, and allowed to cool and shrink under pressure.

Fitting Tubes.—Holes to be chamfered on outside. Tubes to be set with a Dudgeon expander, to be beaded down at each end.

Nozzles, Etc.—Nozzles, manholes, etc., to be of such design that the proportions of the whole will be as strong as any portion of the shell of like area.

Smoke-uptake.—All joints, especially that at head of shell, to be smoke-tight.

"In general all workmanship is to be first-class in every respect."

Inspection and Test

Access to the works of inspector to be afforded at any time during manufacture. Boiler to be tested to (———) pounds hydrostatic pressure, and must be made tight under this pressure. Test to be made in presence of an inspector of the (———) Engineering Co., or (at the option of the engineers) a sworn statement of satisfactory performance of test to be furnished.

Painting

To be painted on outside one coat of mineral paint at shop. Finished surfaces to be covered with a rust-resisting compound.

Packing and Shipping

Flanges to have protectors bolted on. Steam-drum to be shipped separately; small pieces to be boxed and wired, boxes numbered and contents given in shipping list.

Marking

All pieces to be marked for shipment as per instructions in formal order.

Outline of Specification for a Self-supporting Steel Smoke-stack

(Intended to accompany a drawing of a completely designed stack. For outline of design see p. 73. In case an outline drawing only is submitted with the specification, the items in the "General Description" should be as detailed as possible.

Heading as per example, p. 92.

Drawing No. (——)

"These specifications refer to the above drawing of the (————) Engineering Co., and are intended to cooperate with same."

General Description

Main dimensions; inside diameter, height, diameter at base-ring

Anchorage: bolts, anchor-girders, bridge-girder (over pedestal flue opening), base-plate, brackets on stack.

Brichin connection(s); size, location and reinforcement, division diaphragm.

Top: lotus or platform, lightning conductor, etc.

Details: ladder, clean-out door, painting trolley, etc., angles on inside for supporting lining.

Conditions of Bids

Bids are requested for one (1) stack as follows:—

Prop. 1.—For material delivered complete f.o.b./f.a.s. (————) not later than (——) weeks from date of order.

Prop. 2.—For the stack erected complete at (————) not later than (——) weeks from date of order.

Note.—This contractor will not set the anchor bolts or girders.

State estimated shipping weight and submit bids in duplicate.

Material to be Supplied

All metal work necessary for complete construction of stack, including shell, base-plates, anchor bolts and beams, ladder, painters' trolley, platform, railing, lotus, clean-out door, lightning-conductor rivets for all field connections sufficient in 10 percent to 20 percent excess, and a liberal quantity of fitting up bolts.

This contractor *not* to supply any guy-wire; reinforcing bars for concrete base, brichin, damper, nor any concrete or brick work.

Loads

Wind-velocity in miles per hour to which stack may be exposed. Occurrence of, or liability to earthquake shocks.

Proportion of Parts

Maximum allowable stress on anchor-bolts and beams.

Minimum thickness of metal for shell plates; thickness of metal for lotus.

Maximum allowable pressure at toe on concrete or masonry.

Quality of Material

Shell: of (medium) steel plates, 55/65,000 U. T. S., full to gauge and free from flaws.

Lotus: of galvanized steel, copper, etc.

Lightning Conductor: of copper, etc.

Anchor-bolts: of (medium) steel.

Castings: of iron, clean and sound and free from holes, etc.

Workmanship

"To be first-class in every respect."

Specify any special requirements in punching, rolling of plates, etc.

Painting

One coat in shop with an (approved) paint (or oil).

Marking.

All plates, etc., to have marks corresponding to an erection drawing, also all parts to bear shipping marks as per instructions in formal order; marks to be made in such a manner as not to be obliterated in transit, steel stamping dies to be used in addition to paint marks; shipping and erection marks to be in different colored paints.

Inspection

By representative of Eng'rs; rejection of faulty material or material not properly marked.

Boxing and Packing

Knock down for (export) shipment. Small pieces to be boxed and wired, boxes numbered and contents given in shipping list.

Drawings Furnished

Shop drawings to be submitted for approval, contractor to be responsible for dimensions and details on working plans. Anchor-bolt drawings to be supplied within (——) days of date of order. Erection drawings to be supplied when material is shipped.

Delivery of Anchor-bolts

Anchor bolts and beams to be delivered f.o.b./f.a.s. (————) not later than (——) days from date of order.

Outline of Specification for a Medium-speed or Large Steam Engine

(No accompanying drawings. For "inquiry reminders" for smaller engines, see p. 133.)

Heading as per example p. 101.

"Supply one (1) medium speed (or slow-speed) steam engine as per the following specifications of the (———) Engineering Co."

Service and General Description

Describe service sufficiently.

Simple, compound or triple-expansion; tandem or cross compound; single or duplex cylinders; horizontal, vertical or combination frame; girder or rolling-mill frame; R. or L. hand; to run "over" or "under"; centre or side crank.

For direct or belted connection; if the latter, state whether the belt is forward or back of the cylinder, as in the latter case a longer (and larger) crank-shaft will be required so that flywheel may be set out far enough for belt to clear valve gear.

If for direct-connected electric service, consult also "Outline of Specification for a High-speed Engine" on p. 111, for special features.

Type of valve gear preferred, slide, balanced, piston, rotary, Corliss (single or double eccentric), etc.; reversing or non-reversing.

Type of governor; speed control.

Power and Main Dimensions

Initial pressure, back pressure, vacuum; speed; I.H.P. to be developed at (given) cut-off; approximate size of cylinders desired.

Size and weight of flywheel or band-wheel (diameter and face), special type of same, to be supplied in one piece, in halves or sections.

Size of shaft (exact or approximate) at bearings, flywheel and at connection to pinions, etc; if direct-connected always send sketch.

Conditions of Bids

To be for lump sum, for material delivered f.o.b./f.a.s., erected, at (———) not later than (——) weeks from date of order.

Bids to be accompanied by an outline drawing, together with a detailed specification, giving principal dimensions, weight of flywheel, enumerating and describing all fittings, etc.

Estimated shipping weight to be stated.
Bids, drawings and specifications to be submitted in duplicate.

Material to be Supplied

To consist of engine complete with flywheel, out-board bearing, governor, throttle valve, lubricating system for cylinders and bearings, oil-cups, water relief valves, drip and bleeder valves, piston and valve-rod packing, foundation-bolts with nuts and plates, and a complete set of wrenches, spanners and eye-bolts; the whole to be complete and ready for operation when assembled.
Material *not* to be supplied by this contractor (enumerate fully).

Details of Construction

Special features or approximate dimensions desired for crank-pin, cross-head, piston-rod, tail-rod, steam and exhaust connections, throttle valve, governor. eccentrics, oil-cups, forced lubrication, sight-feed lubricators, cylinder-cocks, bleeders, water-relief valves, piston-rings, piston-rod packing, valve-gear, indicator piping.

Quality of Material

Specifications for cylinder and other C. I., crank-shaft forging, wrought-iron details, brass, bearing-metal.

Workmanship

"To be first-class in every respect;" details to allow quick adjustment and repairs without involving work on main material.

Shop-erection and Inspection

Inspection at any time, by representative of engineers. Engine to be erected in the shop; proper dowels to be provided; pieces to be match-marked; faulty material to be rejected.

Painting

Usual or special manner; greasing of bright surfaces.

Marking

All pieces to be marked as per directions of formal order; erection marks.

Boxing and Packing

If for export or any special carriage; small pieces to be boxed and wired; boxes numbered and contents given in shipping list.

Drawings to be Furnished

General dimension, anchor-bolt, erection and detail drawings required.

Shipment of Anchor-bolts

To be shipped within (——) days of date of order.

Erector to be Supplied

Rate per day; payment of traveling and other expenses.

Acceptance Test

Required I.H.P. or B.H.P. to be developed; reliability run; steam-economy requirement; consequent terms of payment (bonus and penalty) as per contract.

Alternate Bids

As required by engineers; or as contractor may desire.

Outline of Specification for a High-speed Steam Engine

(No accompanying drawings.)

Heading as per example p. 101.

"Supply one (1) high-speed steam engine as per the following specifications of the (———) Engineering Co."

Description and Service

Horizontal or vertical; centre or side crank; R. or L. hand; simple or compound; tandem or cross-compound; automatic cut-off; to run "under" or "over;" with or without sub-base; steam-pressure, back-pressure, vacuum.

(If for Belted Connection to Generator.)—For direct or alternating current; K.W. capacity of generator (if for A.C. give K.V.A. and power factor); speed of generator, type and service, and approximate size (diameter and face) of pulley on same; approximate size of engine band-wheel and speed (generator pulley will finally be fixed from same); product of area of piston in inches, length of stroke in inches and R.P.M., not to be less than a (given) coefficient; flywheel.

(If for Direct Connection to Generator.)—For direct or alternating current; K.W. capacity of generator (if for A.C. give K.V.A. and power factor); R.P.M of generator; type of generator; service. Extended base, shaft and out-board bearing to be of A.S.M.E. Standard dimensions; on (given) M.E.P. and speed, product of area of piston in inches and length of stroke in inches not to be less than (given) coefficient; if (A.C.) generator is to run in synchronism with another machine, an extra heavy flywheel to be provided, describe other machine; out-board end of shaft to be extended to take exciter pulley.

Conditions of Bids

To be for a lump sum, for material delivered f.o.b./f.a.s., erected at (———), not later than (——) weeks from date of order.
Outline drawing and detailed description to be furnished.
Estimated shipping weight to be stated.
Bids, drawings and specifications to be submitted in duplicate.

Material to be Supplied

(If for Belted Connection.)—To consist of engine complete with flywheel (s), (and see below).

(If for Direct Connection.)—To consist of engine complete with governor-wheel, extended base to take generator frame, sub-base, extended shaft to take generator armature, outboard pedestal and bearing, eye-bolts and push-off bolts, exciter-pulley (and see below).

(For Either).—Throttle-valve, lubricating systems for cylinders and bearings, sight-feed cylinder lubricator, grease cups, water-relief valves, drip and bleeder valves, anchor-bolt templet, piston and valve-rod packing, foundation-bolts with nuts and plates, and a complete set of wrenches, spanners and eye-bolts; the whole to be complete and ready for operation when assembled.
Material *not* to be supplied by this contractor (enumerate fully).

Cooperation with Electrical Contractor

To cooperate in regard to generator shaft fitting by immediate forwardal to E.C. of detail drawings and template of shaft to enable E.C. to design and manufacture his material to suit, and to preclude any delay in delivery of either generator or engine.

Details of Construction

Special features required in connection with oiling system ("splash" or "positive," reservoir, etc.); cylinder lubricator; outboard-bearing oil-well, capacity and sensitiveness of governor; oil guards; engine shaft (whether to be in one piece, or in two with coupling, etc.).

Shipment of Shaft

To be shipped to generator contractor within (——) weeks of date of order (at expense of owners).

Materials and Workmanship

To be first-class, and in line with the best modern practice; special friction metal; other special material or finish.

Inspection and Test

Inspection by representative to be allowed at any time.

Witness test, length and description; indicator cards to be supplied; requirements to be fulfilled.

Any defect of operation or material to be made good before shipment.

Painting

In usual or special manner; bright surfaces to be greased.

Boxing and Packing

If for export or any special carriage; small pieces to be boxed and wired, boxes numbered and contents given in shipping list.

Marking

All pieces to be marked as per directions in formal order; erection marks.

Drawings to be Furnished

General dimension, anchor-bolt, erection and detail drawings required.

Shipment of Anchor-bolts and Templet

To be shipped within (——) days of date of order.

Outline of Specification for a Direct-connected Electric Generator

(No accompanying drawings.)

Heading as per example p. 101.

"Supply one (1) direct / alternating current direct-connected electric generator as per these specifications of the (————) Engineering Co."

Description and Service

If for Direct Current Service.—Capacity in K.W., voltage; type of winding (shunt or compound).

If for Alternating Current Service.—Capacity in K.V.A. at (————) percent P.F., voltage, phase, frequency.

General.—To be suitable for direct-connection to a high speed / Corliss type, right / left hand engine running over / under at (————) R.P.M.

Dimensions of sub-base, shaft, outboard-bearing, etc.; (supplied by engine contractor) will conform to (A. S. M. E.) standards, and this generator is to be designed to suit same. Use to which generator will be put. Rating, *e.g.*, "The generator is to carry its rated load for 10 hours with a rise in temperature not exceeding 45° C. in any part except the commutator, where the rise is not

to exceed 50° C. Overloads of 25 percent for 2 hours, and momentary overloads of 50 percent are to be carried without injurious heating."
Belted exciter of (———) volts, for drive from pulley on generator shaft or engine flywheel; or steam-driven exciter.

Conditions of Bids

To be for a lump sum for the material complete f.o.b. / f a.s. / erected at (———) not later than (———) weeks from date of order.
Outline drawing giving principal dimensions and descriptive specification to be submitted. Estimated shipping weight to be stated. Bids, drawings, etc , to be submitted in (du)plicate.

Material to be Supplied

For Direct Current Machines.—Generator complete with brush-holders and yoke, ready for installing on engine sub-base, field rheostat.
This contractor *not* to supply the shaft, outboard bearing or base plate, but he will press the armature on the shaft which will be shipped to him (at the expense of the purchaser) for this purpose. Nor will he supply any switchboard, instruments or wiring.
For Alternating Current Machines.—Same as above for direct current machines and also (belted) exciter with slide rails, tightening screws and field rheostat complete; exciter driving pulley; exciter belt.

Cooperation with Engine Contractor

To cooperate with E.C. by forwarding immediately such general arrangement and detail drawings as will enable him to design and manufacture his material to suit, and to preclude any delay in delivery of either generator or engine.

Material and Workmanship

See clause on p. 112.

Inspection and Test

Engineers to be notified when material is completed so inspector may be sent. Apparatus to be given a test-run in the shops of the makers, and copies of performance charts supplied to the engineers. Test-run to be made in presence of the inspector.

Painting

See clause on p. 112.

Marking and Packing

See clause on p. 112.

Drawings to be Furnished

See clause on p. 112.

Outline of Specifications for an Electric Switchboard

The description of the material called for in this outline may be divided into two parts, the first being that covered by the "Service," "General Description," "Finish" & "Rear Connections;" and the second being a supplementary and detailed specification of each item required, as given under the heading "Material to be Supplied." The latter can only be prepared by a skilled electrical engineer.

Such a detailed specification should always be prepared on large and important installations; but it will often happen that a specification for a switchboard must be written by a man having a good general idea of the electrical require-

ments but who is not able to pass on the details. In such cases the first part of the specification, giving the general requirements, may be enlarged upon; while the detailed list of apparatus for each panel may be omitted, the contractor being asked to supply the same with his proposal.

Heading as per example p. 101. (No drawings.)

"Supply one (1) switchboard as per these specifications of the (———) Engineering Co."

Service

Describe the generator outfit, giving number and capacity of machines; kind of current, its voltage, phase and frequency, drive; and method of connection at switchboard.

Describe the load, and any special features concerning it that may affect the design or construction of the switchboard.

General Description

Describe the proposed general arrangement of the switchboard, number of panels, material of panels, number of generator and feeder circuits, method of supporting and bracing, numbering of panels.

Finish

Finish required on the panels, thickness, edges, matching up to existing board. Finish required for the mountings, to be polished, or black, contractor's standard.

Rear Connections

Bus bars to be of copper strap designed for a current density not to exceed (800) amps. per square inch of cross-section, based on the full load current of generators. Main and equalizer buses to be supported on suitable insulated brackets and arranged for extension in both directions.

Branches to switches to be designed for a current equal to the ampere rating of each switch; they may be supported on the switch studs.

Ammeter shunts to be so placed as to give best circulation of air.

All connections to be complete between instruments and switches mounted on the board, and suitable lugs to be provided to make all connections external to the board.

Conditions of Bids

To be for a lump sum for the material complete f.o.b /f.a.s./erected at (———) not later than (—) weeks from date of order.

Estimated shipping weight to be stated in bid. Bids to be submitted in (du)-plicate.

(Note.—In case a detailed list of instruments is *not* given below under the heading of "Material to be Supplied" the contractor should be called upon to furnish such a list with his bid.)

Alternate quotation desired for the board made of different material to that specified.

Material to be Supplied

The material to be supplied by this contractor will consist of the switchboard complete with all switches and instruments (necessary for performing the service indicated above)/(listed below), all buses and other connections necessary to connect them, all lugs necessary to make connections to external circuits.

This contractor will *not* supply the generator field rheostats nor any connections or wiring external to the switchboard.

Panel No. 1 for Control of (———) K.W. Generator

Enumerate and describe the circuit-breakers, voltmeter, ammeters, rheostat, main switch, ground detector outfit, lamp bracket, and shade, swinging bracket with illuminated dial, station voltmeter, etc.

Panel No. 2 for Feeders.

Enumerate and describe the meters, switches, lamp bracket and shade, card holders, etc.

Quality of Material

"All material to be of the best and suitable to the use intended."

Workmanship

"To be first class throughout."

Inspection

Inspection by representative to be allowed at any time.

The switchboard to be set up in the shop, and when completed the engineers are to be notified so that final inspection may be made.

Reservation of right "to reject any and all parts of the work which are faulty in material or construction and not strictly in accordance with the specification and approved diagram of connections."

Boxing and Packing

If for export or any special carriage; small pieces to be boxed and wired, boxes numbered and contents given in shipping list.

Marking

Packages to bear shipping marks as per instructions in formal order.

Drawings to be Furnished

"As soon as possible after receipt of order the contractor shall forward to the engineers for approval, two copies of the diagram of connections and sketch of board, one copy to be returned signed and the other retained by the engineers for their file."

Erection drawings to be provided, also photographs of front and back of board, at time of shipment of materials.

Outline of Specification for a Centrifugal or Turbine Pump

(Notes.—It is supposed that there are no accompanying drawings, except a sketch showing hand and position, etc. Pumps of this character of anything above the smaller sizes are often bought with a guarantee of capacity and efficiency, the price being fixed by a bonus and penalty or rejection clause—see "Conditions of Bids.")

Heading as per example p. 101.

"Supply one (1) Centrifugal or Turbine Pump as per the following specifications of the (———) Engineering Co."

Service

General.—Describe briefly and in a general manner the service to be performed, number of units, whether the pumps are to be used for draining a mine, irrigating, pumping condensing water, etc., continuity of service, power to be

Capacity.—U. S. gallons per minute or per 24 hours.

Quality of Water.—Fresh or salt (give sp. gravity), clear or gritty, acidulous or otherwise corrosive, temperature, source (lake, driven-well, sump, etc.).

Suction Head.—Distance from level of water to engine-room floor (or to centre-line of an existing suction connection), horizontal length and diameter of suction pipe, bends in same (if complicated send sketch), describe in detail, describe variations in suction head. Note effect of altitude upon suction lift.

Discharge Head.—Distance from engine-room floor (or centre-line of an existing discharge connection) to level of reservoir or centre-line of discharge outlet; describe line fully (length diameter, bends, kind of pipe, etc.) so that friction-head can be calculated, or else designate an assumed friction head, or state water pressure to be maintained (at pump discharge). If there is to be any desired variation in the flow, note that for a fixed head centrifugal or turbine pumps will cease to deliver if the speed is reduced about 10 percent, also with a variable head and constant speed the amount of flow varies very considerably.

General Description

Type of Pump.—Single or double suction; horizontal or vertical shaft; if horizontal, the "hand" of pump and relative desired positions of suction and discharge and direction of revolution (which must agree with the position of discharge opening) must be shown on a sketch (see p. 150); if vertical, state whether pump is to be of the "Submerged Type" (*i.e.*, placed entirely under the surface of the liquid), or of the "Suction Type" (with admission either on the lower or upper side of the impeller), and in any case send a sketch.

Drive.—(1) By Belt; give diameter, face, and R P.M. of driving pulley. Describe the prime-mover, whether steam or internal-combustion engine, motor, lineshaft, etc., and give data as to power, etc.

(2) By Direct-connected Steam Engine; describe type of engine available or desired, if the former give all data as to type, size of cylinder, R.P.M., size of shaft, data for coupling, etc., and in either case give steam-pressure and vacuum available.

(3) By Direct-connected Steam-turbine; if steam-turbine is already available or its make determined, send outline sketch of same and data as to R.P.M. and power, etc.; if both the pump and the steam-turbine are to be supplied by the pump contractor, give all data as to steam-pressure available and whether saturated or superheated (and how much), vacuum, etc.

(4) By Direct-connected Electric-motor; give horse-power and speed of motor, whether direct or alternating, current, voltage, if alternating current give also phase and periodicity. In all cases send outline sketch of motor.

Continuity of Service.—State whether operation will be continuous or intermittent.

Special Features.—Describe any special general requirements not considered under above heads. Are parts to be designed for mule-back or other special transportation?

Efficiency.—Maker to state a guarantee efficiency, payment to be made on basis of efficiency developed at test as per clause in "Conditions of Bids "

Conditions of Bids

To be for a lump sum for the material delivered f.o.b./f.a.s./erected at (———), not later than (——) weeks from date of order.

"Penalty and bonus" performance clause as follows: "It is understood that the pump is to have an efficiency of (———) percent. For each 1 percent increase of efficiency the purchaser agrees to pay $——, and for each decrease below (———) percent a deduction of $——— for each 1 percent

will be made. For fractional percentage proportional payments to be made or deducted. If the efficiency is (———) percent or under, the purchaser reserves the right to reject the pump or make further deductions of $——— for each (———) percent below. In the event that the pumps are rejected for being below (———) percent efficiency, the contractor will either furnish a new pump or such material as is necessary to bring the pump to the required efficiency of (———) percent or reimburse the purchaser for all payments made and expenses incurred on said installation."

Outline drawing and detailed description to be submitted with bid.

Estimated shipping weight to be stated.

Bids, drawings and specification to be submitted in (du)plicate.

Material to be Supplied

Pump.—Complete ready to attach to base-plate, extended shaft for belt-pulley, flexible or rigid coupling, pulley or gear-wheel on shaft, companion flanges on suction and discharge, foot-valve, strainer, suction or discharge gate-valves, check valve (on discharge), taper connections, any part of suction or discharge lines, priming ejector (steam or hydraulic), air-outlet valve, oil-cups, oiling system, pressure and vacuum gauges, foundation-bolts, drip tray.

Prime Mover.—To be supplied or not; if the former, to be complete ready to operate pump, enumerate details, etc., to be supplied as given on other "Specification Outlines." If not supplied, drawings, templets and gauges will be supplied the pump contractor; state who supplies the coupling.

Extended Base.—To be supplied by pump contractor to take (direct-connected) motor, steam-turbine, etc. State whether prime-mover is to be shipped to pump contractor for him to fit to base and coupling, and who pays freight bill (preferably owner).

Spares.—Impeller(s) complete with shaft(s).

Details of Construction

Casing.—Split (vertically or horizontally) or solid, if the latter, the side-plates to be of such a size as to allow removal of impeller without disturbing pump on its bed plate or suction or discharge connections.

Diffusion Vanes.—To be arranged for removal (or not), water friction surfaces to be finished smooth.

Shaft Stuffing Boxes.—To be water-sealed, describe any special requirements.

Impeller.—Water friction surfaces to be finished smooth.

Shaft.—Exposed surfaces to be bronze covered.

Flanges.—To be drilled A. S. M. E. St'd.

Drip Tray.—Describe.

Oiling System.—Oil cups or piped system, describe.

Fittings.—Valves, ejector, gauges, etc., describe types, sizes, materials, makes, etc., desired for each.

Material

Casing.—C. I. Bronze, etc.

Diffusion Vanes.—Bronze, etc.

Impeller.—Bronze, etc.

Shaft.—Of steel (specify quality), bronze-covered where it comes in contact with liquid; or of manganese steel, etc.

Drip Tray.—C. I., galvanized steel, etc.

Pulley.—C. I., steel, wood, fibre, etc.

Pinion (for chain drive).—C. I., steel, bronze, rawhide, etc.

Workmanship

"To be first class in every respect." Give any special requirements.

Inspection and Test

Inspection at any time by a representative of the engineers.

Test to be made in presence of representative of engineers, or sworn statement of satisfactory performance submitted. Readings to be taken and curves plotted for efficiency, delivery, head, etc., and copies to be submitted to the engineers. Test to be made to the satisfaction of the engineers.

Expense of test to be borne by manufacturer.

Painting

See p. 120.

Boxing and Packing

See p. 120.

Marking

See p. 120.

Drawings to be Furnished

See p. 120.

Shipment of Anchor Bolts

See p. 120.

Alternate Bids

See p. 120.

Outline of Specification for a High-duty Steam Pumping Engine

(Notes.—It is supposed that bids are to be requested on a pump, the general type of which is more or less pre-determined; to be in general of some standard make. No drawing, therefore, is supposed furnished with the specification.

For a type of a very complete "general" specification, suitable for use when the specification must be very complete and binding, see Johnson's "Engineering Contracts and Specifications," p. 271 of the 4th edition.

For "inquiry reminders" for smaller pumps, see p. 139.

Heading as per example p. 101.

"Supply one (1) High Duty Steam Pumping Engine as per the following Specifications of the (———) Engineering Co."

Service

Capacity.—U. S. gallons per 24 hours.

Quality of Water.—Fresh or salt (give sp. gravity); clear or gritty; acidulous or otherwise corrosive, temperature, source (lake, driven well, sump, etc.).

Suction Head.—Distance from level of water to engine-room floor (or to center-line of an existing suction connection); diameter and length of suction pipe; bends in same (if complicated send sketch); describe in detail; describe variations in suction head; note effect of altitude upon suction lift.

Discharge Head.—Distance from engine room floor (or center-line of an existing discharge connection) to level of reservoir, or center-line of discharge outlet; describe line fully so that friction head can be calculated, or else designate an assumed head; or state water pressure to be maintained (at pump discharge); describe variations in pressure with corresponding capacities desired.

Steam Pressure.—Working pressure at throttle, maximum pressure, back pressure, vacuum, superheat.

Special Features.—Describe any special requirements of service not considered under above heads; are parts to be designed for mule-back or other special transportation?

General Description

Horizontal or Vertical.
Flywheel or Direct-acting.
Single, Duplex or Triplex.
Simple, Compound or Triple Expansion (Cross or Tandem).
Type of Frame: Rolling Mill, Girder or Fork.
Condensing or Non-condensing.
Steam End.—Type of Valve gear: Corliss, Meyer, Worthington, etc.
Type of Valve: Common slide-valve, piston, balanced, or as per last item.
Type of Governor, and method of service control.
Water End.—Plungers: Inside packed, or Outside packed (centre or end).
Pistons: Cylinder lining, method of adjustment.
Suction and Discharge Valves: Type and area.
Air Chambers: On suction and discharge.
Relief Valves: Number, area and discharge pressure.
Are Suction and Discharge connections to face any particular direction? If so, send sketch.

Conditions of Bids

To be for a lump sum, for material delivered f.o.b./f.a.s./erected at (————), not later than (——) months from date of order.
"Penalty and bonus" performance clause (Refer to "Acceptance Test" clause below).
Outline drawing and detailed specification to be submitted with bid.
Estimated shipping weight to be stated.
Bids, drawings and specifications to be submitted in (du)plicate.

Material to be Supplied

Pump complete with throttle valve; governor; lubricating system for cylinders and bearings; oil cups; water-relief valves (on steam and water cylinders); drip and bleeder valves; piston and valve-rod packing; plunger packing; foot-valve; gate valve on suction; bye-pass from discharge to suction; bye-pass from discharge to drain; revolution-counter; platforms, stairs and railings; glass water-gauges on air-chambers; steam, water and vacuum gauges (give diameter, finish, etc.); clock; name plate; condensing plant (see p. 143); foundation bolts with nuts and plates, and a complete set of wrenches, spanners and eye-bolts; the whole to be complete and ready for operation when assembled.
Also the following *spares;* (——) extra valves, seats, bolts and springs for suction and discharge water-cylinder liners.
Material *not* to be supplied by this contractor (enumerate fully).

Details of Construction

Special features or approximate dimensions desired for any of the items under "General Description"; or for the lubrication systems; stairs and railings; gauge-board and fittings; piston-rod packing; plunger or piston packing and lining; make and type of valves; bearing metal.

Condensing Plant

(See p. 143.)

Quality of Material

Specification for C I. for steam cylinders, pump barrels, etc., and for other C.I. work. Specifications for forgings, brass, etc.

Material for: Water end (C.I. or brass, etc.) plungers or pistons; piston-rods, valves.

Workmanship

To be first-class, etc.; details to allow quick adjustment and repair without involving work on main members.

Shop Erection and Inspection

Inspection at any time by a representative of the engineers. Pump to be erected in the shop, proper dowels to be provided; pieces to be match-marked; faulty material to be rejected.

Painting

Usual or special (for export, etc.) manner; greasing of bright surfaces.

Boxing and Packing

If for export, mule-back or other special carriage; boxing of small pieces; numbering of packages; contents to be given in shipping list.

Marking

All pieces to be marked as per directions in formal order; erection marks.

Drawings to be Furnished

Anchor-bolt, foundation, erection and detail drawings required.

Shipment of Anchor-bolts

To be shipped within (———) days of date of order.

Erector to be Supplied

Rate per day, payment of travelling and other expenses.

Acceptance Test

To be by experts; appointment of same; purpose of test: Delivery, steam-consumption, reliability, duty, probation period, describe in detail; payment on duty basis, penalty and bonus clauses; expenses of test to be borne by———.

Alternate Bids

As required by engineers, or as contractor may desire.

Outline of Specifications for Small Tanks and Miscellaneous Sheet-metal Work

(Intended to accompany design drawings more or less complete. For an example of a specification for a large tank (or tanks) see p. 92.)

Heading as per example p. 92.

Drawings No. ———, ———, and ———, etc.

"These specifications refer to the above drawings of the ——— Engineering Co., and are intended to cooperate with same."

General Description

Describe briefly the service for which material is intended, and call attention to any special features required in its construction.

Conditions of Bids

Bids are to be for a lump sum/pound-price for the material completed f.o.b./f.a.s./erected at (———) not later than (———) weeks from date of order.

Estimated shipping weight of each item to be stated in bid.

Bids to be submitted in (du)plicate.

Material to be Supplied

List of Tanks

No. Req'd	Description	Ship	Drawing No.	Mark
One (1)	Hydraulic Pump Tank, 2 ft. 0 in. dia. × 2 ft. 6 in. with cover.	R.U.	1926	H.P.T.
One (1)	Hot Water Tank, 15 ft. 0 in. dia. × 9 ft. 0 in. with cover	K D.	1846	H.W.T
	etc., etc.			

Above material to be supplied complete as shown on drawings, with erection rivets and bolts 10 to 20 percent in excess, and a liberal quantity of fitting-up bolts.

Material

Plates.—To be of tank steel, best quality, full to gauge and free from flaws.

Castings.—Except as otherwise noted to be of good grey iron, true and free from blow-holes, cracks or other imperfections; brass castings to be similarly perfect.

Fittings.—Specify grade of pipe or fittings required, and give any special requirements.

Workmanship

To be first class in every respect. Seams in plate work to be scarfed wherever necessary and rivets spaced close enough to allow all seams to be caulked water-tight. Rivets in certain tanks to be semi-flush on inside. Finish all surfaces called for on drawing and wherever necessary to secure a first-class job.

Shop Erection and Marking

All plate work that will be shipped knocked down (K.D.) to be set up in shop, reamed if necessary, match-marked and pieces marked to agree with erection drawing. Tank marks also to be placed on each piece. Marks to be placed on both sides of sheets (so same will not have to be turned over to find mark).

Inspection

At any time by a representative of the engineers. Material found defective, or not properly marked, liable to rejection.

Shop Painting

Tanks shipped riveted up to be given (one) coat of (———) colored paint on outside, coat of linseed oil on inside. Tanks shipped K.D. to be given (one) coat of linseed oil all over. Galvanized material not to be painted. Smoke-flues, etc., to be painted with a mineral paint. Bright surfaces to be covered with an anti-rust.

Packing and Shipping

All material to be suitably nested/supported/crated for (export) shipment. Small pieces boxed and wired, boxes numbered and contents given in S/L. Also all material to bear shipping marks and numbers, as per instructions, these marks to be in a *different color paint* to erection marks.

Outline of Specification for a Piping Installation (Scheme No. 1)

(Intended to accompany complete design drawings for a uniform installation of piping, but allowing, by the use of an order list, for the including of extra and miscellaneous material. See also, Fig. 55. For a method of listing more complex installations, see scheme No. 2 below.)

Heading as per example p. 92.

Drawings No. ——, —— and ——

"Supply all the material called for in the following list as described in these specifications and as (partly) shown on the above drawings of the (——) Engineering Co."

"In every case *the list is to govern* and the drawings are to be used only to explain the list."

Condition of Bids

To be for a lump sum for the material called for in the following list delivered f.o.b./f.a.s. at (——), not later than (——) weeks from date of order.

Make of valves and type of steam-traps proposed to be furnished to be stated in bid.

Bids to state estimated shipping-weight and to be submitted in duplicate.

Wrought Iron Pipe

State specifically whether "wrought iron" or "wrought steel" pipe is required; whether of "merchant weight" or "full weight"; to be St'd/E.H./D.E.H.; O.D. pipe to be not less than —— in. thick (suitable for threading); a "length" to be not less than 20 ft. long.

Facing and Drilling

"Except in case of the Vanstone type, all flanges on pipe, fittings, valves, etc., shall be faced straight across with rough finish. All flanges are to be drilled to 'Manufacturer's Std. of 19—.' "

Flanges

Of screwed C.I., or Vanstone type; of Std. or E.H. dimensions and drilling, or vary weight for 12 in. and under and 14 in. and over.

Fittings

To be of C.I./C.S./mall. iron/semi-steel; screwed or flanged; L.P./Std./E.H. weight and dimensions; unless otherwise noted.

Valves

Specify acceptable makes; "to be of the grade known to the trade as 1st Quality"; screwed or flanged; material, I B., B.F. (iron body, brass fitted), brass or special metal; weight L.P./St'd./Med./E.H.; gate valves I.S. (inside screw) or O.S. and Y. (outside screw and yoke), with (bronze screws), (renewable seats).

Gaskets

Corrugated copper, copper rings, asbestos, red or black rubber, leather, brass gauze, etc., etc.

Bolts and Nuts

Bolts to have square heads; nuts to be cold-pressed hexagons.

Filling-in Pieces

Pipe so marked (F.I P.) to be supplied 8 in. longer than called for by drawing; flange on one end to be threaded but shipped loose, pipe at this end to be unthreaded.

Connection to Other Work

"If material to be supplied by this contractor adjoins work of others, bolts and gaskets are to be provided to make complete connection."

Cast-iron Pipe

Thickness; quality; tensile strength of material; imperfections; ends to be bolted flanged/bell and spigot/special; to be asphalt-dipped, painted with asphaltic compound, or otherwise covered.

Spiral Riveted

Quality of plate; thickness; flanges to be of C.I , cast steel, or welded steel; flanges to be of Mfr.'s or R.P. St'd dimensions and drilling; to be galvanized, dipped or coated with asphaltic compound; test.

Fittings; to be of "standard" or "riveted-pipe" weight and dimensions; covering.

Workmanship

"To be first-class in every respect."

Painting

All material to be painted a (given) distinctive color; all boxes to be similarly painted on one side and one end for purposes of identification; finished surfaces to be greased.

Erection Marks

Every piece to be plainly marked with erection marks given in list; color of marks.

Inspection

By representative of the engineers; due notice to be given; any material *not marked*, or otherwise not conforming to this specification to be rejected.

Packing

Valves, etc., to be crated; wooden covers or comp. flanges to be bolted on faced flanges 4 in. and larger; protector-caps on threaded ends of pipe; special packing for export; small pieces to be boxed and wired. (Note.—Above apply particularly to export shipments; domestic shipment, especially car-load, does not need such complete protection. See p. 343.)

Shipping

Shipping marks to be placed on pieces as per directions in formal order; packages to be numbered and contents given in shipping-list.

LIST OF MATERIAL

Air Piping (Drawing No. 999).

All pipe and fittings to have flanged ends.

	Mark
1 12-in. L.R. elbow	AP1
1 piece 12-in. pipe	AP2
1 12-in. × 10-in. × 6-in. tee	AP3
1 piece 10-in. pipe	AP4
2 6-in. nipples	AP5

etc., etc.

and all bolts and gaskets as specified in 10 percent excess of number actually required.

Miscellaneous Water Piping (no drawing)

Mark all "MWP"

20 lengths 5-in. pipe
20 lengths 4-in. pipe
30 5-in. scr. tees,
etc., etc.

Outline of Specification for a Piping Installation (Scheme No. 2)

(Intended to cover more complex lists than can be well handled by Scheme No. 1; the idea being that the lists be divided into "Items" according to the class of piping, and that a separate description be placed at the head of each such division.)

Heading as per example p. 92.

Drawings No. —, — and —. (— drawings)

"Supply all the material called for in the following lists as described in these specifications and as (partly) shown on the above drawings of the (———) Engineering Co.

"In every case *the list is to govern* and the drawings are to be used only to explain the lists."

Conditions of Bids

Bids are to be for separate lump sums on the material of each of the following items, the whole to be delivered complete f.a.s./f.o.b at (———) not later than (——) weeks from date of order.

Item "A".—Live Steam Piping.
Item "B".—Exhaust Steam Piping.
Item "C".—Centrifugal Pressure Piping.
Item "D".—Miscellaneous Piping.

Make of valves and type of steam-traps proposed to be furnished to be stated in bid.

Bids to state estimated shipping weight and to be submitted in duplicate.

Pipe

State specifically whether "wrought-iron" or "wrought steel" pipe is required; whether of "merchant weight" or "full weight"; O.D. pipe is not to be less than ——— in. thick (suitable for threading); weight to be as called for at head of each list.

Facing and Drilling

"Except in case of the Vanstone type, all flanges on pipe, fittings, valves, etc., shall be faced straight across with rough finish. All flanges are to be drilled to 'Manufacturer's Std. of 19—.'"

Valves

Specify acceptable makes: "to be the grade known to the trade as '1st Quality;'" weights and dimensions to be as called for at the head of each list.

Bolts and Nuts

See Scheme No. 1.

Filling-in Pieces
See Scheme No 1.

Connection to Other Work
See Scheme No. 1.

Workmanship
See Scheme No. 1.

Painting
See Scheme No. 1.

Erection Marks
See Scheme No. 1.

Inspection
See Scheme No. 1.

Packing
See Scheme No. 1.

Shipping
See Scheme No. 1.

LIST

Item "A."—Live Steam Piping.

(Working Steam Pressure ——— lb. per square inch)

Pipe.—To be St'd/E.H./D.E.H.; specify thickness of large O.D. pipe.

Flanges.—Of screwed C.I. or Vanstone type; of St'd, or E.H. dimensions and drilling; or vary type for 12 in. and under, and 14 in. and over.

Fittings.—To be of C.I /cast steel/malleable iron/semi-steel; to be St'd. or E.H. weight and dimensions; to be flanged; all unless otherwise noted.

Valves.—To be flanged; of St'd/Med./E.H. weight; to be I.B.B.F.; gate valves to have O.S. & Y., with bronze screws and renewable seats; all unless otherwise noted.

Gaskets.—Corrugated copper, copper rings, asbestos, asbesto-metallic, brass gauze, etc., etc.; cut rings to fit inside bolt holes.

Live Steam for Cond. Water Pumps and for L.-D.-G. Pumping Engine. Drawing No. 2595.

No.	Description	Mark
1	Piece 10-in. pipe.	SG–20
1	10-in. 90° bend	SG–21
2	10-in. angle valves.	SG–23
1	8 × 8 × 12 tee	SG–26
2	1 1/4-in. scr. globe valves.	SG–33
1	6-in gate valve, I.S	SG–40

etc., etc.

Live Steam Header to Small Pumps. Drawing No. 2603.

1	Piece 6-in. pipe.	SG–64
3	6-in. tees.	SG–67
1	Hanger.	SG–68

etc., etc.

and all bolts and gaskets as specified (for Item "A") in 10 percent excess of number actually required.

Item "B".—Exhaust Steam Piping.

(Working Pressure ——— lb. per square inch)
Pipe.
Flanges.
Fittings.
etc., etc.

Outline of Specification for Heat Insulating Covering for Apparatus and Piping

(Intended to accompany drawings which show the principal dimensions of the bodies to be covered: no piping drawings. However, the regular pipe drawings may also be used for the covering contract, especially when the contract is let "erected." When the contract is placed for material "delivered," however, it conduces to closer figuring to submit a list only.

It is essential that the contractor submit an itemized estimate that may be checked by the engineer.)

Heading as per example p. 92.

Drawings No. (——) and (——)

"Supply the material called for in the following list, as described in these specifications and as (partly) shown on the above drawings of the (———) Engineering Co.

General Description

Describe briefly the character of the apparatus, etc., to be covered.

Conditions of Bids

Bids to be for a lump sum for the material complete delivered f.o.b. / f.a.s. / erected at (———) not later than (———) weeks from date of order.
Bidders to furnish an *itemized* list of the material proposed to be furnished, *divided* as per the item marks of the accompanying list.
Estimate shipping weight to be stated in bid.
Bids to be submitted in (du)plicate.

Description and Quality of Materials

For large (cylindrical) bodies (Drwg. No. ———)
To be covered with blocks ——— in. thick of insulating material composed of (85 percent Carbonate of Magnesia and 10 to 15 percent of Asbestos Fibre, etc.), to be securely wired in place and covered with poultry netting. The whole is then to be covered with ——— in. of (Asbestos plastic) cement, covered with 6 oz. canvas and painted with a (drab-colored) fireproof paint.
For large (flat surface) bodies (Drwg. No. ———)
To be covered with a coat ——— in. thick of (Asbestos Cement Felting / Asbestos Cement/etc.). This is to be covered with poultry netting, the whole then covered with 6 oz. canvas and painted with a (drab-colored) fireproof paint.
For Live and Exhaust Steam Piping (no Drawing)
All pipe under 18 in. diameter to be covered with a sectional covering ——— in. thick of insulating material composed of (85 percent Carbonate of Magnesia and 10 to 15 percent of Asbestos Fibre/Fire-felt/etc.), each section being formed in halves, covered with 6 oz. canvas and secured with brass bands and clips at 18-in. intervals. Coat with a (drab) colored fireproof paint before banding.

All piping 18 in. diameter and over is to be similarly covered, but the sectional covering is to be only ——— in. thick.

Covering for Pipe Fittings (No Drawing)

See list.

Packing and Shipping

All material to be suitably packed for (export) shipment, packages marked and contents given in shipping list.

List.

Item No. 1.—Covering for (large cylindrical bodies) as shown on drwg. No.——. Supply blocks, wire-netting, cement, canvas and paint as specified above in sufficient quantity to completely cover.

Item No. 2.—Covering for (large flat surface bodies) as shown on drwg. No.——. Supply cement, wire-netting, canvas and paint as specified above in sufficient quantity to completely cover.

Item No. 3.—Covering for Steam and Exhaust Piping as follows:

Size	20 in.	18 in.	14 in.	12 in .	10 in.
Lin. Ft.	90	110	40	420	220

Item No. 4.—Covering for Pipe Fittings, (No drawing). Supply (———) bags of ——— lb. each of (Asbestos Cement Felting / Asbestos Cement / etc.).

Outline of Specifications for an Installation of Transmission Machinery

(Intended to accompany complete design drawings for an installation of shafting, hangers, etc., but allowing, by the use of an order list, for the including of extra or miscellaneous material.)

Heading as per example p. 92.

Drawings No. ——, ——, and ——

"Supply all the material called for in the following list as described in these specifications and as (partly) shown on the above drawings of the (———) Engineering Co.

In every case the list is to govern and the drawings are to be used only to explain the list."

General Description

Describe briefly the extent and service of the installation, emphasizing any special requirements or conditions.

Conditions of Bids

Bids are to be for a lump sum for the material complete f.o.b / f.a s. / erected at (———) not later than (———) weeks from date of order.

Bids are to be accompanied by sketches and descriptions of the material proposed to be furnished.

Bids, etc., to be submitted in (du) plicate.

Details of Construction

Shafting.—Cold-rolled, hammered steel, etc. May be supplied in other lengths than called for if necessary to hasten delivery.

Couplings.—Flange, sleeve or other type; method of securing to shaft; all bolts to be supplied.

Hangers.—Standard or extra heavy; plain or babitted boxes; ring-oiling or plain; ball and socket; etc. All bolts for securing to be supplied in 10–20 percent excess.

Friction Clutches.—Specify special make or type; style of shifting device, levers by owners or contractor?

Pulleys.—Single or double-belt weight and dimensions. Material (C.I., steel, wood, etc.), if all are similar. Type (solid or split) if all are similar.

Material

All to be the best of its respective kind, suitable to use intended.

Workmanship

"To be first-class in every respect."

Painting

All material (except wearing surfaces) to be given one coat in shop; bright surfaces to be covered with an anti-rust.

Erection Marks

See p. 123.

Inspection

See p. 123.

Packing

Parts having same erection marks to be packed together as far as possible; special packing for export; small pieces to be boxed and wired.

Shipping

See p. 123.

Drawings to be Furnished

For location of anchor-bolts, etc., of floor-stands; and of hangers.

List of Material

Counter Shaft for Liming Tanks (Drwg. No. 1981).
Mark all material "LT."
1—2 3/16 in. Shaft 23 ft. 4 in. long., in two pieces
2—2 3/16 in. Safety Collars.
4—2 3/16 in. R.O., B. and S., C I. 21 in. drop hangers.
3—15 in. × 9 in. C.I., S.F. pulley K.S. and S.S. for 2 3/16 in. Shaft.
1—24 in. × 6 in. C.I., C.F., ditto,
etc., etc.

Extra Material (Not shown on drawings).
Mark all material "EX"
4—2 3/16 in. safety collars
1—18 in. × 6 in. C.I.,D.B., C.F., split pulley, K.S. and S.S. for 2 7/16 in. bore
etc., etc.

Outline of Specification for Leather Belting

(For supplementary notes, see p. 185.)
Heading as per example on p. 101.
(No drawings).

"Supply the material called for in the following list, as per these specifications of the (————) Engineering Co.

Conditions of Bids

Bids to be for separate lump sums for the material of each item of the list delivered f.o.b./f.a.s. at (————) not later than —— weeks from date of order.

Bids to be submitted in duplicate; estimated shipping weight to be stated.

Quality of Material

(The following specifications for quality, etc., are extracted from an article by C. B. Avez in the "Amer. Machinist" for May 25, 1911, describing the specifications of the W. E. & M. Co. For small orders, only the clause on "Material" need be used.)

Material.—Belting to be of best quality of oak-tanned leather, free from all ingredients in anyway injurious to the life or wearing qualities of a belt, or that simply adds to its weight.

Location of Cuts.—Belting must be cut longitudinally.

Under a strong magnifying glass the way in which the leather has been cut, whether longitudinally or crosswise, may generally be determined by the follicles or hair cells, and if their direction is other than longitudinal this may be considered cause for the rejection of the length of belting under inspection.

Laps.—Laps must not be less than 4 in., nor more than 8 in., except that in single belting 8 in. and over in width, the lap may be 1 in. longer than the width of the belting; no lap should be within 4 in. of the end of a strip.

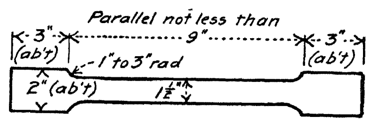


FIG. 25.—Test piece for leather belting.

Laps must be thoroughly cemented, and when pulled apart, the exposed surfaces must not show any resinous, vitreous, oily or watery condition; no rivets will be permitted.

Weight.—Belting not waterproofed must come within the following range of weights, which must be guaranteed to be not more than 10 percent in excess of the actual weight of the leather.

Single Belting

Width in inches	Minimum weight, ounces per square foot
1 to 2	13
2 1/4 to 4	14
4 1/2 to 5 1/2	15
6 and over	16

Double Belting

1 to 2	24
2 1/4 to 4	26
4 1/2 and over	28

Physical Properties.—Belting is to have a U.T.S., both in leather and splice, of not less than 3600 lb. per square inch, and must not show an elongation in 2 in. to exceed 13 1/2 percent when measured under a load of 2,250 lb. per square inch for 1 hour.

The belting must not crack open on the grain side when doubled strongly by hand with the grain side on the outside; nor must it show piping or raising on the grain side when similarly treated with the grain side on the inside.

Test pieces as shown above will be cut from belting with a die.

When belting is required for any special purpose, the manufacturer will be notified as to H P., speed, etc.

Rejection.—Rejected material will be returned to manufacturer or seller for full credit at price charged f.o.b. point of delivery specified by purchaser.

Packing and Shipping

This material is to be properly packed for (export) shipment.

All packages are to bear marks as called for in order; and shipping-lists, etc., furnished as required.

List

Item "A."—Belts for Machine Shop

Length	Size	Thickness
75 ft.	1 1/2 in.	Single
75 ft.	2 in.	Single
250 ft.	3 in.	Double
50 ft.	5 in.	Double

Six (6) doz. of belt laces

Item "B."—Belts for Carpenter Shop

Length	Size	Thickness
75 ft.	2 in.	Single
75 ft.	3 in.	Single
150 ft.	3 in.	Double
250 ft.	4 in.	Double
300 ft.	6 in.	Double
	etc., etc.	

Six (6) doz. of belt laces

Outline of Specification for a Freight or Passenger Elevator

(Specifications for a freight or a passenger elevator should invariably be accompanied by a complete drawing of the hatchway. An exception might occur in the case of a wooden building where an elevator of the required size being purchased, the hatch could be built to suit the elevator. The drawing should show a plan at each floor giving the beam-framing and location of exits; elevations of the hatch framing showing bracing, location of overhead beams, enclosing grills, etc.; and the desired position of the winding engine or other motor located. After bids and proposal drawings are received the original plan may be modified to suit the machine chosen.)

Heading as per example p. 92.

Drawing No. ——.

"These specifications refer to the above drawing of the (————) Engineering Co., and are intended to cooperate with same.

Description

Service.—Freight/Passenger; in a (——) story factory/loft/etc., building.

Power.—Belt operated from line-shaft at (——) R.P.M. with intermediate countershaft; or belted or direct-connected electric motor drive (give voltage of current, and, for A C , phase and frequency); or, hand-power (state proposed location of operators); or, water power (state whether from street main, roof tank or pressure tank, giving pressures); or steam engine (state steam pressure); or, compressed air (state pressure available).

Maximum Load to be Lifted.—(In pounds.)
Average Load to be Lifted.—(In pounds.)
Travel.—Distance in feet, and number of landings.
Speed.—(————) feet per minute with maximum load (or ask manufacturer to recommend speed).
Hatch Construction.—See drawing.
Size of Car.—Give approximate size of platform desired. (Note.—The final size will be determined by the dimensions of the hatch and the arrangement of guides, counterweights, etc.)
Type of Car.—Of steel frame with wood or steel floor; all wood, iron fitted. Wainscoated on (————) sides, wainscoating to be of steel strap/wire/wood strips/etc. Gates on car (?), type desired.
Method of Car Control.—From car, outside control (describe requirements); to be of makers standard type.
Guide Posts.—Of wood; or, of steel angles with maple face; or, of steel "Tee" section.
Counterweight Guides.—Same as for guide posts.
Overhead Work.—To be supported on wood/steel beams.
Cables.—Manilla/iron/steel rope (for important work specify quality)
Safety Appliances.—Limitation stops; safety-brake on machine; slack-cable stop; safety grips on car.
Indicators.—State whether required or not, and any preference for type.
Hatch Enclosure.—Wood, steel-strap, wire-net, ornamental iron, sheet steel, etc.
Hatch Gates.—Positive control or automatic (self-opening and self-closing); lifting, sliding, pantograph, or other type; of wood, wire net, ornamental iron, sheet steel, bronze or other construction.
General.—"A completed drawing of the contiguous steel framing will be furnished this contractor at the time of placing of order."

Conditions of Bids

Follow example p. 92.

Material to be Supplied

Elevator complete including car, all wire cables, all sheaves, counter-balance outfit, safety appliances, all guides, winding machine, countershaft complete for direct and reverse drive, (split steel) pulley for line-shaft, exit gates and controlling device.

Also all steel beams, etc., necessary to support the overhead, winding machine, countershaft and guides that are shown by heavy lines on the drawing; and all bolts, rivets, etc., necessary to erect the equipment furnished with about 10 percent excess.

This contractor will *not* supply any of the hatch framing or building steel work, shown on the drawing by faint lines, nor the hatch enclosing grilles, nor any belting.

Materials and Workmanship

To be first-class in every respect.

Inspection

Material subject to inspection at any time by a representative of the (———) Engineering Co.; faulty material, etc., subject to rejection.

Painting

State requirements. Finished surfaces to be greased.

Marking

Follow example p. 95.

Packing and Shipping

Follow example p. 95.

Drawings to be Furnished

"As early as possible after date of order, the contractor shall forward to the engineer, two complete sets of general arrangement drawings for approval. One of these sets when approved will be returned signed to the contractor, and the other will be retained by the engineer for his file.

Also at the time of shipment of materials the contractor shall forward to the engineers, one set of erection drawings on cloth and two sets on paper and any further sets reasonably required."

CHAPTER IV

REMINDERS FOR OBTAINING QUOTATIONS ON STANDARD MATERIAL

Introduction

The following "reminders" are intended for the use of engineers, superintendents and others who may have occasion to ask for prices and proposals on standard machinery and material, such as small steam-pumps, boilers, industrial track and rolling-stock, etc., etc. The greater part of this matter has been compiled or extracted from manufacturers' catalogues, but the endeavor has been made to combine (and also add to) the items in several catalogues, so that the list of reminders may be of a more general and more complete character.

It would seem to be almost superfluous to point out the fact that by submitting information as complete and definite as possible to the manufacturers in the first place, much closer prices can be obtained with a minimum of delay and with a greater certainty that the material finally supplied will be satisfactory and best suited to its purpose. The advent of a fully conditioned inquiry, however, is an exceptional occurrence in an agent's or manufacturer's office; the latter either writes for more definite information, or submits three or four propositions in the hope that one of them may hit the mark; in either case each bidder usually does two or three times the amount of work that would have been necessary had definite information been submitted to him in the first place, and the buyer ultimately has to pay for this. The delays and dissatisfaction which may occur, are, of course, accentuated in the case of export business.

The reminders given may also be used as the basis for a specification arranged according to the system described in the preceding chapter, in case it is desired to present the requirements in a more formal manner.

SEC. I. COMPLETE MACHINES

Throttling, Medium-speed Steam Engine

The following outline is written from the standpoint of an owner requiring an engine for a certain service, but who does not know, or does not desire to assume, a definite size of engine. In most cases, however, an engineer will prefer to state (subject to later revision) the size of cylinder and the R.P.M.; and in this case the outline may still be con-

sulted with advantage, the data being submitted in a slightly different order.

(1) **Service.**—Describe character of machinery to be driven and any special features of its operation which may affect running of engine.
(2) Give speed of shaft to be driven, and size of pulley on same if one is in place or proposed.
(3) Give steam pressure at throttle and state whether engine will exhaust to the atmosphere, against a back-pressure or into a vacuum, giving figures.
(4) **Type of Engine Desired.**—Single or double cylinders; horizontal or vertical; centre or side crank; reversing or non-reversing; ordinary slide valve and gearing, or other type of valve and gear (describe requirements); right-hand or left-hand (for side-crank engines only); standard or extra-heavy bed.
(5) Will engine run "over" or "under"?
(6) **Flywheel and Bandwheel.**—Is a bandwheel desired in addition to flywheel, or is the belt to be used on flywheel alone? In the former case, state position desired for the bandwheel.
(7) Speed of engine, and size of bandwheel (diameter × face). If any of these dimensions are known, they should be stated.
(8) **Power.**—The power requirements may be stated in either of the following ways, the first being the most indefinite, and the last most complete and liable to result in the closest bidding.
   (a) State the brake horse-power required to operate the machinery, and the steam pressure expected at the throttle of the engine; leaving the speed to be fixed by the manufacturer from information in (2).
   (b) State indicated horse-power to be developed and pressure at throttle; speed being fixed by manufacturer from information in (2).
   (c) State indicated horse-power to be developed, pressure at throttle and R.P.M. of engine.
   (d) State indicated horse-power to be developed, mean effective pressure to be assumed in calculation, and R.P.M. of engine.
   (e) State size of cylinder and R.P.M. of engine.
(9) **Fittings.**—State specifically which of the following fittings are to be furnished; governor and belt; automatic safety stop on governor; throttle valve; sight-feed cylinder lubricator; oil cups; force-feed oiling system; indicator piping; oil can; foundation bolts; sub-base; cylinder drain pipes and valves; flange coupling on shaft (for direct-connection); water-relief valves; bleeder valve for steam-chest; (special) piston and valve rod packing; wrenches and spanners; eye-bolts; and also state what are *not* to be furnished.

Standard Fire-tube Boiler of Horizontal Tubular, Vertical Tubular, Locomotive, Etc., Types

(1) **Number of Units Required.**
(2) **Style of Boiler Required.**—(a) Horizontal Tubular, (b) Vertical Tubular, (c) Locomotive Type, (d) Marine or Scotch Type, (e) "Manning" Type, (f) "Economic" Portable, (g) Cornish Type (Single flue), (h) "Galloway" Type (Double Flue), (i) "Elephant" Type, (j) Special.
(3) **Horse-power or Size of Each Unit.**—State requirements in one of the following ways:
   (a) (Nominal) Horse-power.
   Note.—This is the least satisfactory method of stating the size required, as there is no uniformity among builders as to the rating or method of

measurement. It is a general practice, however, to allow 1 h.p. for every 10 sq. ft. of heating surface, but the method of measuring this surface varies; see next paragraph.

(b) **Square Feet of Heating Surface.**—State the square feet of heating surface required, whether measurement is to be made on inside or outside of tubes, whether one-half or two-thirds of the circumference of the shell of a horizontal tubular boiler is to be counted, whether the tube-sheet surfaces are to be included; and, in case of special boilers, specify what surfaces are to be included in the measurement.

Note.—The usual rule is to consider as heating-surface all surfaces that are surrounded by water on one side and are exposed to flame or hot gases on the other.

(c) **Size.**—Give the principal dimensions of the boiler required (*i.e.*, diameter and length), state the number and size of tubes, dimensions of fire-box or grate-flue, etc.

(Note.—For outline of a M.T. boiler design see p. 74, and for specification see p. 106.)

(4) **Working Pressure and Factor of Safety.**—State the working pressure, test pressure (50 percent more than W.P.), and least factor of safety on shell-plates and stays or braces.

(5) **Arrangement.**—State whether boilers are to be set singly or arranged in batteries of two, three, four, etc.

(6) **Settings, Supports, Etc.**

(a) Horizontal Tubular Boilers.—State whether boilers are to have a standard "full front" (with a large flush cast-iron front carrying furnace, ash-pit and smoke doors) or a standard "half front" (with smoke-box projecting and C.I. front carrying furnace and ash-pit doors only), or state special requirements. Is front of boiler to be "flush end" or is shell to be extended to form a smoke-box?

Also state whether the boiler is to be carried by lugs directly on the brickwork, or suspended from beams overhead carried on the setting, or suspended from beams and columns independent of the brickwork. Any special requirements should be stated.

(b) Vertical Tubular Boilers.—These are usually set on a C.I. base. State whether a submerged or full-length tubular type of boiler is desired.

(c) Locomotive Type Boilers.—These are usually mounted on skids carrying C.I. brackets; for permanent settings the brackets can be set on concrete or masonry.

(d) Marine or Scotch Type Boilers.—Same as (c). They may also be set on built steel cradles.

(e) "Manning" Type Boilers.—These sit on a C.I. base.

(f) "Economic" Portable Boiler.—Same as (c).

(g) (h) and (i) Cornish, "Galloway" and "Elephant" Boilers. These are usually carried on C.I. or built steel pedestals, and the brick setting built around the boilers.

(7) **Furnace Construction.**

(a) Fuel.—State whether coal, wood, sawdust, bagasse, oil, briquettes, etc., are to be burned, so that proper grate may be furnished.

(b) Type of Furnace and Grate.—State whether a regular furnace is to be used, or a special style such as a "Dutch-oven," oil-burning, step-grate, automatic, etc.

Also state any particular style of grate bar desired, "Herring-bone," shaking, etc.
State whether forced or natural draft will be used.
For Locomotive Type boilers, state whether "open" or "water" bottom furnaces are desired.
For Marine, Cornish or "Galloway" Type boilers, state whether plain or corrugated flues are required.

(8) **Dome, Steam Drum or Dry Pipe.**
State which is preferred, and give special requirements.

(9) **Flue and Stack.**
Is each boiler to have a separate stack, or are batteries to be connected by a smoke-flue to a single stack?
If smoke flue is required, give distance center-to-center of boilers and state whether connection to stack will be on right, left or center.
Give location of stack with reference to center-line of nearest boiler.
Is a guyed or a self-supporting stack preferred? How will stack be set? Is a stack plate wanted?

(10) **Fittings.**
Safety Valve(s), pop or lever?
Steam Gauge and Syphon.
Water Column and Connections.
Low-water Alarm.
Glass Water Gauge and Gauge Cocks.
Main Steam Valve.
Injector, check valve, stop valve, and internal feed pipe for Boiler Feed.
Blow-off Cock or Valves.
Whistle.
High-water Alarm.
Note.—State any special make, size, etc., required on any of the above.

(11) **Export Work.**
If work is for export, state whether pressed-steel outlet flanges, loose lugs, etc., are desired; so as to cut down measurement, facilitate rolling and avoid breakage. For large boilers, the tubes may be shipped separately and expanded in at destination, thus decreasing the weight to be handled; the bidder should be so informed.
If for mule-back transportation, the boiler will have to be shipped completely k. d., plates in small sizes.

(12) **Material to be Supplied**
Enumerate precisely the material to be supplied, and also the material *not* to be supplied, checking by the proper list given below.

(a) Horizontal Tubular Boilers.
Boiler(s) complete with steam-drum/steam dome/dry-pipe; C.I. front with doors, anchors and dead-plate; grate complete; tee and angle bar (or plate) for rear; carrying lugs; suspension rods; suspension beams; supporting columns; wall plates; rollers; fire door; arch plate; rear soot door, frame and anchors; buckstays and bolts; stack plate; smoke flue; damper; stack with guy wires; firing tools; and fittings as enumerated in (10) above.

(b) Vertical Tubular Boilers.
Boiler(s) complete with base plate; fire-door; grate bars; hood; smoke

stack and guy wires; damper; flue; firing tools; and fittings as enumerated in (10) above.

(c) Locomotive Type Boilers.
Boiler(s) complete with steam-dome/steam-drum/dry-pipe; rear stand and brackets on side of firebox; skids; fire-door; grate and bearing bars; rear soot door; smoke flue; damper; smoke stack with guy-wires; firing tools; and fittings as enumerated in (10) above.

(d) Marine or Scotch Type Boilers.
Boiler(s) complete with steam-dome/steam-drum/dry-pipe; supporting lugs/steel cradles; skids; furnace front with doors; grates complete; firebrick for bridge-wall; combustion-chamber end complete with soot-door; fire-brick lining for same; front smoke-box; smoke flue; damper; smoke stack with guy wires; firing tools; and fittings as per (10) above.

(e) "Manning" Type Boiler. Same as (b) above.

(f) "Economic" Portable Boilers. Boiler(s) complete with steam-dome/steam-drum/dry-pipe; supporting lugs or brackets; skids; furnace complete, including casing, fire-doors, grate and bearing bars, bridge wall and firebrick lining; combustion-chamber complete with doors and firebrick lining; smoke box extension with door; smoke flue; damper; smoke stack with guy wires; firing tools; and fittings as per (10) above.

(g) Cornish Type and (h) "Galloway" Type Boilers.
Boiler(s) complete with steam-dome/steam-drum/dry-pipe; C.I. or built steel cradles; furnace doors; grates complete; bridge wall; fire brick for bridge wall; soot-door; damper complete; firing tools; and fittings as per (10) above.

(i) "Elephant" Type Boilers. Follow schedule for Horizontal Tubular Boilers, (a) above.

Water Tube Boiler

(1) Number of Units Required.

(2) Style of Boiler Required.

(a) Straight tubes inclined, connected to sectional headers, with longitudinal drum; *e.g.*, Babcock & Wilcox.
(b) Same as (a) but with steel-plate headers, *e.g.*, Heine.
(c) Same as (a) or (b) but with drums placed cross-wise (low headroom type).
(d) Straight tubes vertical (or nearly so), drum top and bottom; *e.g.*, Wickes, Cahall.
(e) Curved tubes, drum (or drums) top and bottom; *e.g.*, Stirling.
(f) Curved tubes attached to a central vertical drum; *e.g.*, "Climax."
(g) Short, straight, closed tubes attached to a central vertical drum; *e.g.*, "Porcupine."

(3) Horse-power or Size of each Unit.

State requirements in one of the following ways:

(a) (Nominal) Horse-power.
Note.—This is not an altogether satisfactory method of stating the capacity required, as there is no uniformity among builders as to the rating or method of measurement. It is a general practice, however, to allow 1 h.p. for every 10 sq. ft. of heating surface, but the method of measuring this surface varies; see next paragraph. At the same time it must be understood that some types of W.T. boilers are more efficient than others, and when experience has demonstrated such superiority, an allowance should be made in favor of the more efficient type.

(b) **Square Feet of Heating Surface.**
State the square feet of heating surface required, and whether measurement is to be made on inside or outside of tubes (latter preferable for W.T. boilers). Note —The usual rule is to consider as heating-surface all surfaces that are surrounded by water on one side and are exposed to flame or hot gases on the other.

(4) **Working Pressure and Factor of Safety.**
State the working pressure, test pressure (for tubes and for drums), and least factor-of-safety on shell-plates and stays or braces. Require builder to state F.S. on special details.

(5) **Arrangement.**
State whether boilers are to be set singly, or arranged in batteries of two, three, four, etc.

(6) **Settings, Supports, etc.**
The method of setting W.T. boilers is so dependent upon the construction of the boiler, that designs of settings have become standardized, and it is unnecessary to specify construction. It is often desirable, however, to require that the boiler be supported on a steel staging independent of the brickwork.

(7) **Furnace Construction.**
Follow (7) of Outline for F.T. Boiler, p. 135.

(8) **Superheater.**
Superheaters are variously placed inside the boiler-setting between the tubes and the drum (of straight, inclined tube types of W.T. boilers), above the boiler-setting in a chamber to which the flue-gases may be bye-passed, and in a separately fired furnace. It should be remembered that superheat demands an extra expenditure of fuel, and that accessibility for cleaning and repairs and safety and durability are important factors in a decision as to its adoption; good engineering advice should, therefore, be obtained concerning a proposed installation. Bidders may be asked to quote on their standard apparatus.

(9) **Flue and Stack.**
Follow (9) of Outline for F.T. Boiler, p. 136.

(10) **Fittings.**
Follow (10) of Outline for F T. Boiler, p. 136.

(11) **Export Work.**
Follow (11) for Outline for F.T. Boiler, p. 136.

(12) **Material to be Supplied.**
Enumerate items to be supplied from list below, and also state which are *not* to be supplied.
Boiler(s) complete with suspension framing; steam-drum (for connecting two or three units); C.I. front with doors, anchors, and dead-plate; grate complete; buckstays, bolts, tee-irons, and all other metal work required for complete setting; special brick for smoke-baffles; wall-plates; rollers; rear and side cleaning doors; superheater complete with piping, valves, dampers, etc., ready to connect to installation; stack-plate; smoke-flue; damper; stack with guy-wires; all special wrenches, etc., required; tube scrapers; firing-irons; fittings as enumerated in (10) above; and spare tubes, nipples, flanges, bolts, etc., in about (———) percent excess of total number in boiler (to be given as a separate price).

Small Steam Pumps

Two sets of "reminders" are given below, the first for the use of inquirers who can give only the running conditions affecting the size and style of pump, and the second for the use of those who have determined definitely the size and style required.

Outline No. 1.—(For use when size and style is left to the bidder.)

(1) For what kind of service is pump to be used?
(2) Kind of liquid? Clear or gritty? Salt, fresh, or acid? Hot or cold (give temperature)?
Note.—Hot water or other liquids cannot be raised to any considerable height by suction, and this difficulty increases with the temperature. If the water is so hot as to vaporize when the atmospheric pressure is removed, the pump must be placed so that the water will flow into the pump by gravity, *i e.*, under a head. Thick liquids should always flow to the pump under a head, the amount depending on the density of the liquid pumped.
(3) Height of suction, *i.e.*, vertical distance from surface of water to center-line of pump? Also give length, diameter, material and general arrangement of suction pipe, so that friction may be allowed for.
(4) Discharge head, *i.e.*, vertical distance from centre-line of pump to discharge outlet or to surface of water (whichever is greatest) or pressure against which pump will operate? In the former case, give also the length, diameter, material and general arrangement of discharge pipe, so that friction head may be computed.
(5) Capacity. Give maximum number of U. S. gallons (231 cu. in) per minute.
(6) Steam pressure at pump. Give lowest pressure at which pump will have to operate.
(7) Exhaust. State whether pump will exhaust into atmosphere, into a condenser, or against a back pressure. If the latter, give the pressure.
(8) Is a simple or compound steam end desired?
(9) Is a single or duplex pump preferred?
(10) Are foundation-bolts or sight-feed cylinder lubricators to be furnished?
(11) Are any spare valves, seats and springs; or any other spares to be furnished?
(12) Repair Parts. In ordering repair parts always give size and shop number of pump.

Outline No. 2.—(For use when size and style is specified by the purchaser.)

(1) Service?
(2) Size (d × D × s = diameter of steam cylinder × diameter of water cylinder × stroke). Single or Duplex, etc.?
(3) Class of Pump. Direct acting, flywheel, etc.; Hor. or vert.; Simple, compound or triple expansion; Piston-pattern, plunger and ring, or outside-packed (centre or end) plunger type?
(4) Details of Steam End. Working steam pressure? Specify if any particular type of valve gear, cylinder construction, etc., is required.
(5) Details of Water End. Working pressure? To be of C.I., composition or other metal? Cylinders to have drawn-brass or cast composition linings, etc.? Comp. linings to be fixed or removable? Ends to be "standard" or of special "sugar-house" type? Air chamber of iron or copper?

(6) Details of Water Valves. To be of rubber, brass or other metal? Required area in proportion to discharge?
(7) Details of Water Piston. To be of C.I., composition-covered or solid brass? Piston-rod to be of steel or bronze?
(8) Details of Plungers. To be of C.I. composition-covered or solid brass?
(9) Other Details. Describe any special requirements not listed above. Are sight-feed lubricator and foundation bolts to be supplied?
(10) Are any spare valves, seats and springs; or any other spare parts to be furnished?

Air Compressors: Data Required for Recommendations as to Size, Number, Etc.

The following schedule is from a form issued by the Westinghouse Air Brake Co.

General

(1) For what purpose, in a general way, will air be used?
(2) Air pressure required?
(3) Could this pressure be raised or lowered somewhat if desirable? If so, how much?
(4) Number of cubic feet of free air required per minute?
(5) Will amount of air stated in (4) be used continuously or only intermittently?
(6) If intermittently, about what proportion of time will it be in use?
(7) What is your altitude above sea level?

Steam Driven Plants

(8) Steam pressure at the compressor?
(9) Would it be possible to raise steam pressure if desirable? If so, to what pressure?
(10) How much nominal horse-power of boiler capacity can you spare for the compressor?
(11) Is there any condition necessitating compressor of small weight?
(12) Specify those of the following accessories which you will wish us to furnish with the compressor:

Steam Valve	Reservoir Drain Cock
Lubricator	Cocks (size and how many)
Pump Governor, Type and Size	Air Gauge
Reservoir, Capacity Required	Reducing Valve
Pump Stand	Water-control Valve
Hose Couplings	Safety Valve
Nozzles	

Motor Driven Plants

(13) Direct current or alternating current?
(14) If alternating { What Phase? / Alternations per Minute?
(15) Voltage at compressor?
(16) If current available for compressor is limited, how many amperes can be spared?
(17) In case of alternating current, does same current connect with heavy induction load?
(18) Specify those of the following accessories which you will wish us to furnish with the compressor:

Electric-pump Governor	Insulating Hose Connection for discharge pipe
Insulating joint for Governor Pipe	Fuse Block
Switch	Reservoir Drain Cock
Reservoir, Capacity Required	Cocks (size and number)
Air Gauge	Reducing Valve
Safety Valve	Water-control Valves
Hose Couplings	Starting Unloading Device
	Nozzles.

Belt Driven Plants

(19) What is speed of driving shaft in revolutions per minute?
(20) What is maximum allowable size of pulley on driving shaft?
(21) If driving power is limited, how many horse-power can be spared for the compressor?
(22) Specify those of the following accessories which you will wish us to furnish with the compressor:

Pump Governor	Cocks (size and number)
Reservoir, Capacity Required	Reducing Valve
Reservoir Drain Cock	Safety Valve
Air Gauge	Nozzles
Hose Couplings	Water-control Valve.

Air (Vacuum) Pump for Steam Engine Condensation Service

(Note.—For air pump for evaporating condensation service, see p. 142.)

(1) What is the type of engine, simple, compound or triple expansion?
(2) How many pounds of steam are to be condensed per hour; or, what is the diameter of steam cylinders and the length of stroke of engine, the R.P.M. and the maximum point at which steam is cut off?
(3) What is the steam pressure of the boiler? and at the engine throttle?
(4) If possible, send indicator cards from the engine.
(5) What is the size of engine exhaust connection?
(6) State whether the pump is to operate on the wet system, the dry system, or with surface condensation.
(7) Give size and description of condenser, together with a statement as to its efficiency and capacity to do the work required of it.
(8) What is the maximum temperature of water to be used for injection? Is water fresh or salt?
(9) Degree of vacuum desired (barometer at 30 in.).
(10) Available floor space, if limited.
(11) **Type of Pump.**—State which of the following types is desired or preferred, or state whether the type may be proposed by the contractor.

Steam-driven

(a) Single Piston Horizontal Direct Acting ("Scotch") Type.
(b) Duplex Piston Flywheel (Horse-shoe Bed) Type.
(c) Single Piston "Center Crank" Flywheel Type.
(d) Rotative Dry Vacuum Type, Single or Duplex (with mechanically operated inlet valves and spring actuated discharge valves).

(e) Vertical Flywheel "Suction Valveless" Single Acting ("Edwards") Type, Single or Triplex.
(f) Vertical Single Acting Twin-beam Type (for Wet Systems).

Power-driven
(g) Rotative Dry Vacuum Type, Single or Duplex (see (d) above), operated by belt or geared to an electric motor.
(h) "Edwards" Type Pump (see (e) above), operated by belt or by gearing from a steam-engine or electric motor.

(12) **Driving Power**
(a) For Steam Power; give pressure at throttle, and state whether exhaust will be to atmosphere, against a back pressure, or into a vacuum, giving figures.
(b) For Power Drive. Follow item (7) for Power Pumps, p. 151.
(c) For Geared Connection to Motor. Follow item (8) for Power Pumps, p. 151.
(d) For Geared Connection to Steam Engine. Follow item (9) for Power Pumps, p. 151.

(13) **Material to be Supplied**
(a) For Steam Driven Pumps. Follow item (9) for Steam Engines, p. 134; and also state whether any spare valves, seats and springs, or other spares are to be furnished.
(b) For Power Driven Pumps. Follow item (10) for Power Pumps, p. 151; and also state whether any spare valves, seats and springs, or other spares are to be furnished.

Air (Vacuum) Pump for Evaporating Condensation Service

(Note.—For air pump for steam engine condensation service, see p. 141.)

The following items apply more particularly to the conditions encountered in raw cane-sugar factories, where a very large percentage of the vacuum pumps engaged on evaporating work are to be found. The suggestions may be readily applied, however, to other conditions of service.

(1) State kind of material to be concentrated.
(2) What quantity of liquid will be concentrated in a given time, and about what percentage will be evaporated?
(3) Is pump for dry or wet system?
(4) Condenser Data.—Note.—For small factories, wet condensers are often used, usually attached to the pump; for larger factories, the dry system is usually adopted, and the following questions apply to the latter more particularly.
State whether the pump is to be used on an "individual" condenser, *i.e.*, connected to one apparatus only; or on a central condensing system. Is condenser of the counter-current or parallel-current type?
If possible, submit B/Ps or sketches of the condenser, as it is important to know what provision is made for cooling the air and incondensible gases prior to their entering the vacuum pump.
(5) Vacuum Pans.—Give number and type of pans; whether of coil or calandria type; square feet of heating surface in each; cubic capacity of each, together with that of save-all and vapor pipes up to cut-off valve or condenser.
(6) Evaporators.—Give (for each apparatus) number of cells; square feet of heat-

ing surface (tubes only) in each cell; cubic capacity of evaporator, its vapor pipes and catch-all up to cut-off valve or condenser.

(7) Give cubic capacity of other main vapor pipes and central condenser.

(8) Temperature of condensing water used?

(9) Temperature of discharge water from condenser?

(10) Vacuum desired? (Barometer at 30 in.)

(11) Is a cooling tower used?

(12) Average tons of cane ground per 24 hr., extraction obtained and maceration water used in percent of normal juice?

(13) Miscellaneous.—Source of water supply? Have water-supply pumps water-sealed stuffing boxes? Do they discharge to condenser direct, or is there a tank or stand-pipe interposed?

(14) Available floor space, if limited?

(15) Type of pump. See item (11), p. 141.

(16) Driving power. See item (12), p. 142.

(17) Material to be Supplied. See item (13), p. 142.

Feed Water Heaters

Notes.—Feed water heaters are of two kinds, "open" and "closed." The "open" type is used on the suction side of the feed pump where the feed water is not under pressure, and the "closed" type is used on the discharge line to the boilers and the water is therefore under boiler pressure. The selection of the type to be used must be determined by the owner or engineer; the data indicated below should be submitted when asking for prices.

Open Type Heater

(1) Capacity.—Type and H.P. of boilers to be supplied; type, size, R.P.M., initial pressure, etc., of engines supplying exhaust steam.

(2) Feed Water.—Temperature of feed water desired, and temperature of cold feed water.

(3) Utilization of Exhaust Steam.—Is the steam to be used also in a heating system? If so, describe the system, giving data as to area of radiating surface, etc.

(4) Oil separator.—Give any special requirements.

(5) Give size of exhaust pipe connection.

(6) Number of units required.

Closed Type Heater

(7) Capacity.—Type and H.P. of boilers to be supplied; type, size, R.P.M. initial pressure, etc., of engines supplying exhaust steam; or specify amount of heating surface (I.D. or O.D. of tubes) required, and whether steam is to flow through or around the tubes.

(8) Feed Water.—Temperature of feed water desired, boiler pressure carried, temperature of cold feed water.

(9) Utilization of Exhaust Steam. Same as (3).

(10) Give size of exhaust pipe connection.

(11) Number of units required.

Condensing Apparatus for Steam Engines and Turbines

(1) State the number and size of steam turbines to be installed; or the number and size of steam engines, pumps, etc., and whether simple, compound or triple expansion.

(2) How many pounds of steam are to be condensed per hour; or, what is the diameter of steam cylinders and the length of stroke of the engine, the number of revolutions per minute, and the maximum point at which steam is cut off?
(3) State the full load rating and amount of overload. For how long a period will the overload occur, and during what season of the year?
(4) What is the steam pressure of the boiler? Amount of superheat, if any?
(5) What is the maximum temperature of water to be used for injection? Is water fresh or salt?
(6) If possible, send indicator cards from the engine.
(7) What is the size of engine exhaust outlet?
(8) What is the distance vertically and what is the distance horizontally from the surface of the water supply to the floor of room where condenser will stand?
(9) How many inches of vacuum are desired?
(10) What type of Condenser is preferred; a Surface Condenser, a Jet Condenser on the Wet System, a Jet Condenser on the Dry system or any variation of either of the above types?
(11) If auxiliaries are to be motor driven, furnish full particulars of current characteristics.
(12) Are alternate quotations desired on any other system that may be proposed by the manufacturer?

For Surface Condensing Plant

(13) Is condenser to be located on engine-room floor or in basement? If located in basement, give head room.
(14) Indicate the material required on this installation; condenser, air-pump, circulating pump, hot well, hot-well pump, air cooler, and connecting piping; and state any preference as to type of pump and arrangement of the installation.

For Wet System Jet Condensing Plant

(15) Is the condenser to be located on engine-room floor or in a basement? If located in basement give head room.
(16) Indicate the material required on this installation; jet condenser, automatic vacuum-breaker, vacuum pump, steam end (or power drive) and valves and piping; and state any preference as to style of pump and arrangement of the installation.

For Dry System Jet Condensing Plant

(17) A sketch showing location of engine pump and exhaust pipe and indicating where it is proposed to set the condenser, hot well, etc., should be submitted.
(18) Indicate the material required on this installation; condenser, air-cooler, fall pipe, vacuum pump (describe type required and give conditions), air-piping, injection water pipe and valves, and supports for condenser.

Cooling Tower

(1) **Service.**
State whether the tower is to cool condensing or other water; for a brewery, sugar factory, etc.; and whether the water is acidulous or otherwise destructive.

(2) **Location.**
State whether the tower will be located on top of a building or on the ground. Also state the town and country where tower will be located.

(3) **Conditions of Operation.**
(a) State capacity required, *i.e.*, gallons of water in circulation per minute.

(b) Give the temperature of the ingoing water (stating whether degrees Fahrenheit or Centigrade).
(c) State how many degrees it is desired to cool this water. Note.—If no figure can be given for this, bidders may be requested to guarantee a reduction in temperature, or to submit several bids on different guaranteed reductions.
(d) Temperature of atmosphere.—State the usual temperatures at different times of the day, in summer and winter. Also state the maximum and minimum temperatures that may be expected, and the frequency of their occurrence.
(e) Humidity.—State the average relative percentage of humidity throughout the day, in summer and winter. Also state the maximum that may be expected, and the frequency of its occurrence.
(f) Wind.—Describe the constancy, direction and force of the wind throughout the day; also state any other characteristic that may have effect on the design of the cooling tower.

(4) **Material to be Supplied.**—A cooling tower is composed of the following parts: Main frame, distributing troughs, cooling trays or slats, ladder and spray preventers. Each part may be made of either wood or steel (usually galvanized), and the construction desired should be specified, as the prices will be materially different. Also piping from the base of the tower to the distributing troughs should be called for if desired. The collecting tank or pond may be of concrete, sheet steel, wood, etc.; if to be furnished, the construction desired should be stated.

Fuel Economizer

(1) Describe briefly the style of installation to which economizer is to be adapted and submit a drawing showing the general arrangement of the plant, space in which it is proposed to place the economizer, etc.
(2) State the number, type, size, etc., of boilers to be fed; so that amount of water to be heated can be calculated (usually on basis of 30 lb. per B.H.P. per hour).
(3) Boiler pressure carried?
(4) Grade of coal or other fuel to be used; and type of grate?
(5) Diameter and height of smoke-stack? If forced draft is used, describe the system.
(6) Temperature of feed-water entering economizer?
(7) Temperature at which feed-water must leave economizer?
(8) Will the tube-scraping device be driven from an independent steam engine or electric motor, or a line shaft?
(9) Is any provision to be made for future enlargement of plant? If so, describe proposed extensions.
(10) Material to be supplied.

The following material is usually supplied as part of the regular equipment; the tubes and headers, blow-off valve, safety-valve, scrapers complete, gearing mechanism complete, driving pulley, deflector plates, soot doors, and all bolts, etc., required to completely erect.

The following material is *not* regularly supplied; the dampers for the smoke-flues for bye-passing the economizer, the driving engine or belt, the brick for the setting, the structural steel for carrying the setting (in case same is elevated), the T-irons, etc., for carrying the roof of any brick approach-flues, nor any asbestos cement for insulating the top of the economizer.

In inquiring for prices, enumerate such of the above items as are to be supplied, and also those that are *not* to be supplied.

Mechanical Draft Equipment

The following particulars, regarding proposed or present plants in which it is desired to install mechanical draft equipment, which should be submitted to manufacturers of this material to obtain estimates, are taken from the catalogue of the Green Fuel Economizer Co.

(1) Average amount of water evaporated per hour.
(2) Average amount of coal burned per hour.
(3) The greatest rate of evaporation at any period during the day or year.
(4) The character of the coal used.
(5) The type of grate bars.
(6) The number, type and size of the boilers.
(7) The size and length of the flues, also number of bends.
(8) The size and height of chimney.
(9) The intensity of draft obtained at the base of the present chimney.
(10) The draft obtained in the furnace at present.
(11) The thickness of fuel bed usually carried.
(12) The steam pressure.
(13) How much exhaust steam at atmospheric pressure is there at present available in the plant and in what manner is it utilized?
(14) Is it desired to increase the capacity of the plant at any future time and, if so, by how much?
(15) In addition to the above information, plans or drawings should be supplied which will show the space available for the location of forced or induced draft fans, flues, etc.

Belted Electric Generator

(1) For direct or alternating **current** service?
(2) **Voltage?** If A.C., state also phase and frequency.
(3) **Capacity?** If D.C., state in kilowatts; if A.C., state in kilovoltamperes at ——— percent power factor (usually 80 to 100 percent).
(4) **Service.**—Describe sufficiently, so that a suitable type of generator may be proposed. State approximate percentage of overload and its duration.
Will generator run in parallel with other machines?
(5) **Speed.**—High-speed generators cost less than low-speed but are more apt to give trouble in operation. If possible, therefore, give a limiting maximum speed, or call for alternate quotations on low and high-speed machines.
If for belted connection to an existing engine, give R.P.M., diameter and face of engine pulley; if for belted connection to a line-shaft, etc., give R.P.M. and diameter of same; so that a generator of suitable speed may be proposed.
(6) **Temperature Rise.**—Specify any requirements, or ask bidder to state his guarantee.
(7) **Type.**—If decided, state type of generator required as indicated by following list:
   (a) Direct-current Generators.
   Shunt-wound.
   Compound-wound.
   Three-wire generator.
   (b) Alternating-current Generators.
   The ordinary alternating-current generator as manufactured to-day is invariably of the "Rotating Field" type, with either two-phase or three-

phase windings; for single-phase service three-phase windings are used, the load being carried (at a reduced output) by any two leads of the three-phase winding.

(8) **Exciter.**—(For A C. Machines only.)
State whether this is to be driven by belt from generator shaft, by direct-connection to generator shaft, or as a separately driven unit.

(9) **Starting and Regulating Devices.**
The field rheostat is usually furnished with the machine; the other material, on large installations at least, had best be ordered separately. (See p. 113.)

(a) Direct Current Machines.
Field rheostat, circuit breaker, switch, voltmeter, ammeter, ground lamp, and panel of switchboard to carry same.
If two or more generators are to operate in multiple, an equalizer will also be required.

(b) Alternating Current Machines.
Field rheostat, D.C. ammeter, D.C. voltmeter and field-discharge switch (all for exciter); ammeter, voltmeter, voltmeter receptacle, ammeter receptacle, main switch, ground-detector outfit, main fuses, and panel of switchboard to carry same.
If for parallel operation with other generators, a synchronizing outfit will also be required.

(10) **Material to be Supplied.** State which of the following items are to be supplied and also which are not to be supplied.

(a) Direct Current Generator.
Machine complete with pulley, base-plate with slide rails and tightener for floor/wall/ceiling mounting, field rheostat, switchboard and instruments (as listed, see "9–a" above), and spare parts (as listed).

(b) Alternating Current Generator.
Generator complete with pulley, base-plate with slide rails and tightener, driving pulley for exciter; belt driven/direct-connected exciter with tightening base, driven pulley and field rheostat; switchboard and instruments (as listed, see "9–b" above), and spare parts (as listed).

(11) **Number of Units** Required?

Electric Motors

Intended, primarily, for the inquirer who can state only the working conditions, leaving to the bidders the proposing of a suitable motor. The electrical engineer, however, will usually prefer to state definitely the type desired; see (7) below.

(1) For direct or alternating **current** service?
(2) **Voltage?** If A.C., state also phase and frequency.
(3) **Horse-power** to be developed, if known? If not known, amplify information called for by (4).
(4) **Service.**—Describe sufficiently, giving sizes or capacities of machines operated. State whether service is continuous or intermittent, constant or varying, and state the approximate percentage of overload and its duration. State whether open or enclosed type is required (a/c working conditions.)
(5) **Speed.**—State whether this is to be constant, *e.g.*, line-shaft service; multi-speed (two-speed, three-speed, etc.), *e.g.*, fan service; adjustable-speed (variable over a considerable field, but when once adjusted of constant speed),

e.g., lathe service; or varying-speed (speed varying with load, decreasing with increased load, and *vice versa*), *e.g.*, crane or street-car service. State the speed (or speeds) required if known; or, if not decided, give the R.P.M. of the shaft to be driven, etc., so that a motor of suitable speed may be proposed (in this case it is well to state a maximum allowable speed, as the price varies greatly with the speed.)

(6) **Temperature Rise.**—Specify any requirements, or ask bidder to state his guarantee.

(7) **Type.**—If decided, state type of motor required as indicated by following list:
(a) Direct Current Motors
Shunt-wound
Series-wound
Compound-wound
Differentially-wound
(b) Alternating Current Motors
Synchronous
Induction
Squirrel-cage for constant speed
Squirrel-cage for variable speed
Phase-wound for constant speed
Phase-wound for variable speed

(8) **Driving Connection.** For each case, give information indicated.
(a) Pulley on armature shaft; give diameter and face if decided, or ask for standard or proposed size; state style of pulley desired, C.I , paper, etc.
(b) Pulley on reduction shaft of back-geared motor; give information as for (a).
(c) Spur-gear pinion on armature-shaft, or on reduction-shaft; give pitch-diameter, face, number of teeth, style of teeth; or give same information for driven gear or chain and ask for suitable pinion; state style of pinion desired, C.I. steel, rawhide, etc.
(d) Coupling on armature-shaft, or on reduction-shaft for direct-connection to pump, line-shaft, etc. If coupling is to be furnished by motor contractor, indicate type desired (flange, flexible, etc.), and give exact (not nominal) diameter of driven shaft.

(9) **Mounting.**—State whether motor is to be mounted on:
(a) Foundation direct without use of C.I. base, requiring only foundation-bolts.
(b) Common base-plate of direct-connected pump, etc., requiring dowels and bolts.
(c) C.I. base with rails and tightening screws, requiring also foundation bolts. State whether for floor, wall or ceiling mounting.

(10) **Starting and Regulating Devices.**—Every motor of any size must be provided with some sort of rheostat, compensator or controller for starting and regulating, and this should, preferably, be ordered as part of the equipment. Switches and fuses may also be called for, the whole mounted on a suitable board.

(11) **Miscellaneous.**—Gear-case for back-geared motor. Volt-meter, ammeter, or other instruments for starting board.
Wiring, etc., for distant control.
Belt-tightener attachment.

(12) **Material to be Supplied.**—State which of the following indicated items are to be supplied, and also which are not to be supplied.
Motor as described above complete with, (a) pulley, gear, etc., as per (8)

above; (b) base-plate, etc., as per (9) above; (c) rheostat, switch, etc., as per (10) above; (d) miscellaneous attachments as per (11) above; (e) spare parts.

(13) **Number of Units** Required?

Constant-potential Static Transformers for Lighting or Power

(1) Number of transformers required?
Note that for three-phase work, three single-phase or one three-phase transformer may be used per circuit, depending on circumstances
For three-phase transformer state whether "Star" or "Delta" connection is to be used.
(2) Capacity in K.W., allowing for power-factor of load?
(3) Method of cooling? Oil-cooled and air-cooled in small sizes; air-blast and water-cooled in large sizes.
(4) Step-up or step-down? State primary and secondary voltages wanted.
(5) Frequency?
(6) Describe service.
(7) Bidders to state temperature rise, efficiency and regulation of their transformers.
(8) Primary cut-outs, hangers (for small sizes), and oil to be included in price.

Small Centrifugal Pumps

Note.—For outline of specification for larger (special) units, see p. 115.

(1) Number of pumps required.
(2) Capacity of each in U. S gallons per minute.
(3) Normal and maximum suction lift (vertical, to floor), length, size and kind of suction pipe.
(4) Discharge head (vertical, from floor), length, size and kind of discharge pipe.
(5) Friction Heads.—Give an assumed friction head; or, if there are any bends or obstructions in the pipe line, describe same so that friction head may be estimated.
(6) Variation in lift, both suction and discharge, if any.
(7) Quality of liquid; fresh water, gritty, acidulous, solids in suspension, etc.
(8) Temperature of liquid (deg. Fah.).
(9) Specific gravity of liquid.
(10) Service; describe briefly, stating whether continuous or intermittent, etc.
(11) Drive.—State kind of drive, giving the information indicated under the proper (or relative) heading below.
  (a) Belted.—Give R.P.M. of shaft, and the maximum diameter of driving pulley desirable, or the diameter of existing (engine or motor) pulley.
  (b) Direct-connection to electric motor. For direct current, give voltage; for alternating current, give voltage, frequency and phase.
  (c) Direct-connection to steam engine or steam turbine. Give steam pressure and state whether operating condensing, non-condensing or against in back-pressure.
(12) Type of pump preferred. State any special requirements; such as special material (other than C.I.) for casing, for impeller, etc.; single or double suction; position of suction and discharge; maximum R.P.M. allowed.
(13) Will motive power be furnished by the pump manufacturer or by others? If by others, is pump to be built right- or left-hand? (See diagram.)

(14) Is pump contractor to furnish sub-base to take both pump and motive power?

(15) If motive power is furnished by others, is the motor to be fitted to the pump by the pump contractor? Which contractor furnishes coupling?

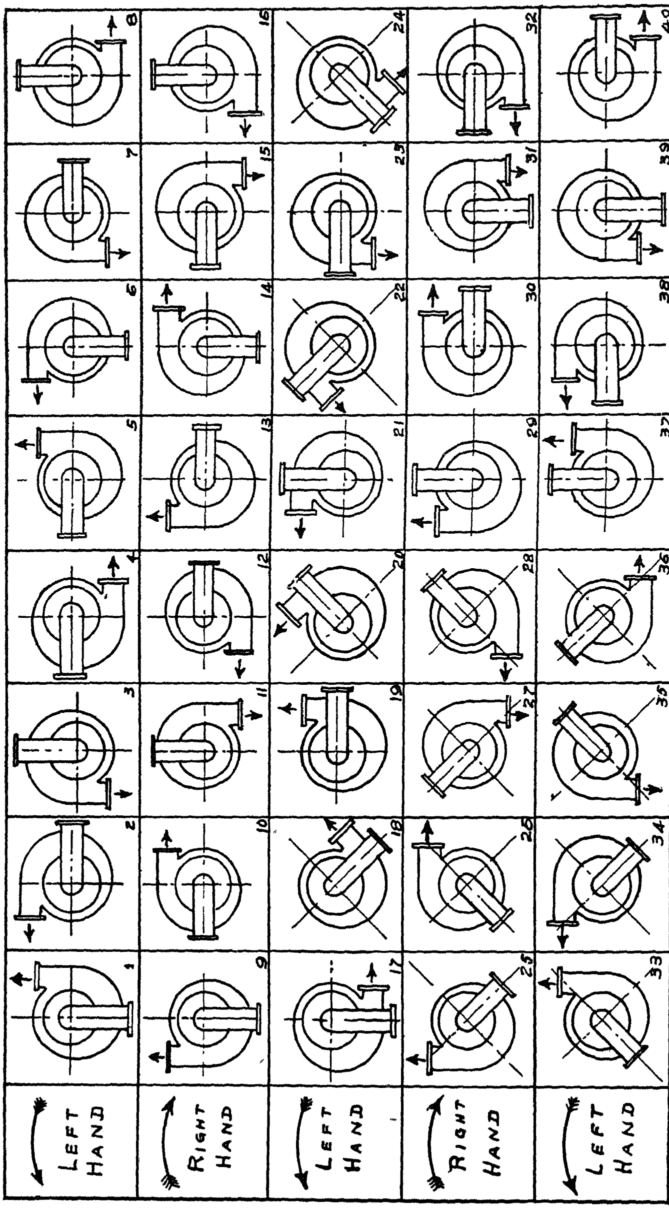


FIG. 26.—"Hand" and "position" of centrifugal pumps, looking from suction side (for a single-suction pump), or from side opposite to driving pulley or coupling (for a double-suction pump). Note 1. Makers differ as to direction of "hand," that shown above ("right" hand for direction of hands of a watch and vice versa) is most common; always send sketch. Note 2. For double-suction pumps, suction at 45° down is impossible, as it interferes with the base.

Note.—If motor is not to be fitted to pump, pin gauges and keyway gauges should be exchanged.

(16) "Position" of pump. Indicate by sketch, taken from diagram above, the

required position of suction and discharge openings, and the required direction of rotation.

(17) Miscellaneous.—Is a (steam or water) ejector required for priming? Are any foot, gate, check or other valves required with pump? Are any spare parts to be furnished? Are foundation-bolts to be supplied?

Power Pumps (Triplex, Etc.)

(1) Service.—For what use is pump intended?
(2) Capacity: number of U. S. Gallons per minute, average and maximum?
(3) Liquid: fresh water or other liquid, salt, gritty, acidulous, temperature (deg. Fah.), etc.? If other than fresh water, give the specific gravity.
(4) Suction head: vertical distance from water-level to floor line; size, length and material of pipe line?
(5) Discharge head: vertical distance from floor line to level of discharge; size, length and material of pipe line? Or give pressure (in pounds per square inch) against which pump will discharge.
(6) Friction head: give an assumed figure, or describe any bends or obstructions in the pipe line so that friction may be figured.
(7) If for Belted or Rope drive: give R.P.M. of driving shaft, and maximum or desired diameter of pulley; or, for Engine or Motor drive, give R.P.M. and diameter of driving wheel or pulley if known.
(8) If for Geared Connection to Motor: give kind of current and voltage, and, if alternating, give also frequency and phase. If motor is selected, give its H.P., R.P.M., make and class (or send sketch).
(9) If for Geared Connection to (Steam) Engine: state steam pressure and whether operating condensing, non-condensing or against back-pressure. If engine is selected, state its (cylinder) size, R.P.M., make and class (or send sketch).
(10) Is the pump contractor to furnish the motive power? If not, make arrangements for interchange of sketches and templets, and state who furnishes the gearing, etc., and state whether motive power is to be shipped to the pump so the whole may be fitted in the shop.
(11) Are any spare valves, seats and springs, or other spare parts to be furnished?

Deep Well Pumps

(1) For what purpose is the pump to be used?
(2) What is the maximum and the average U. S. Gallons per minute required to be pumped.
(3) Is the water clear or gritty?
(4) Is well cased with Standard Wrought Pipe or Artesian Well casing?
(5) Inside diameter of well casing?
(6) Depth of well?
(7) Depth of well casing? If water is found in sand, is strainer properly set?
(8) Depth to surface of water?
(9) If surface discharge or suction pipes are now in position, give diameter and length, and state number of turns and valves in each.
(10) Give vertical distance to which water must be forced, or against what pressure.
(11) Give power available to run pump, or, if none is on hand, state style of power preferred.
(12) State style of pump preferred.

Air Lift Pumping Outfit

Lifting and forcing water, brine, acids and other liquids by means of compressed air has attained large and extended adoption within the last few years. The system has special advantages in certain circumstances, notably when a number of adjoining wells have to be pumped, and when the presence of sand, etc., in the water would forbid the use of a piston pump.

The design of an installation suitable to the conditions presented is a recognized specialty, and in probably no other class of inquiries is it more essential that correct and complete data be furnished to the engineering department of the manufacturers.

The following "reminders" are those contained in the information-blank issued by the Ingersoll Rand Co.

Information Needed for Estimate on Air Lift Pumping Outfit

(1) How many wells are to be pumped?

(2) Entire depth:
No. 1 ———ft. No. 2.———ft. No. 3———ft. No. 4———ft.

(3) Inside diameter casing at top;
No. 1———in. No. 2———in. No. 3———in. No. 4———in.

(4) If inside diameter is reduced, state at what depth below surface and to what diameter:
No. 1 at———ft. No. 2 at———ft. No. 3 at———ft. No. 4 at———ft.
to———in. to———in. to———in. to———in.

(5) If any further reduction in diameters state fully below:

No. 1. . . . .
No. 2. . . . .
No. 3. . . . .
No. 4 . . . .

(6) To what depth is well cased?
No. 1———ft. No. 2———ft. No. 3———ft. No. 4———ft.
Is casing air tight?. . . . . .If not, where is leak. . . . .

(7) What make, length, diameter and depth to strainers?
No. 1 . . . . Bottom open or closed?
No. 2. . . . . Bottom open or closed?
No. 3 . . . . Bottom open or closed?
No. 4. . . . . Bottom open or closed?

(8) How far below the surface does the water stand when not pumping?
No. 1———ft. No. 2———ft. No. 3———ft No 4———ft.

(9) If well flows, how many gallons per minute at surface?
No. 1 ——— gal. No. 2 ——— gal. No. 3 ——— gal. No. 4 ——— gal.

(10) What natural head or pressure do they have at surface when closed?
No. 1 ——— lb. No. 2 ——— lb. No. 3 ——— lb. No. 4 ——— lb.

(11) If wells have been pumped, at how many gallons per minute?
No. 1 ——— gal. No. 2 ——— gal. No. 3 ——— gal. No. 4 ——— gal.

(12) How far below the surface did the water-level fall when giving the above quantity.
No. 1 ———.ft. No. 2 ——— ft. No. 3 ——— ft. No. 4 ——— ft.

(13) At what depth below the surface is the water obtained?
No. 1 ——— ft. No. 2 ——— ft. No. 3 ——— ft. No. 4 ——— ft.
(14) Was the pump used a suction, deep well or air lift?
(15) State all cylinder diameters, length of stroke, speed, and whether duplex or single?
(16) How far above the ground surface must the water be raised? ——— ft
(17) How far horizontally from the well is it to be discharged?
No. 1 ——— ft. No. 2 ——— ft. No. 3 ——— ft. No. 4 ——— ft.
(18) What horse-power of boiler can you spare and what steam pressure do you carry?——— H.P. ——— lb.
(19) Can you use a belt-driven Air Compressor?............................
H.P. available... ... .
(20) What is the source of water supply; sand, gravel or rock?
(21) How many gallons per minute do you require? ——— gal.
(22) When there are more than one well please make sketch showing location and distances, and write any other remarks on back of this sheet.

Water Wheels, Water Turbines and Impulse Wheels

Notes.—Both the mathematical and practical efficiency of water wheels, water turbines and impulse wheels are matters of design and adaptation to conditions; complete information as to qualifications should therefore be supplied to the manufacturers in order to obtain the most efficient machine.

Water Wheels are usually built in sizes from 10 ft. to 30 ft. in diameter, and are best adapted for driving slow-moving machinery.

Water Turbines are usually built for heads of from 4 to 100 ft. in standard sizes, but machines for taking heads up to 250 ft. or more can be built. It must be remembered that there is a more or less definite relation between the speed and power of a turbine for a given head, which must be observed to obtain the greatest efficiency, and the speed should not be arbitrarily fixed; see item (3) p. 155.

Impulse Wheels (of which the Pelton is the best known type) are particularly adapted to higher heads (up to 2,000 ft. and more) although they are built for heads as low as 20 ft. They can be constructed for quite a wide range of speeds, and are thus well adapted for direct-connection.

It will be seen that the fields of each type of wheel overlap very considerably; and, in the case of turbine wheels, there is also a great variety of types of settings. For the larger and more important installations, therefore, it is imperative that the services of an hydraulic engineer be obtained to design a plant giving the best results at the least cost. For smaller units, however, the submitting to the manufacturers of the information outlined below, will conduce to the probability of obtaining from their engineering forces recommendations as to the most efficient installation to suit the conditions.

General Data (Applying to all Types of Wheels)

(1) Amount of water available in cubic feet or gallons per minute; or in miners' inches (state head over centre of opening in measuring box). Note.—For methods of measuring flow of water see p. 25. Do *not* give as the water supply an amount that will fill a certain size of pipe, calculations based on such information being unreliable.

(2) State whether the above quantity is at maximum, minimum or average flow; and give quantities at these three periods.

(3) Head: state vertical head (level of tail water to level of head water); also state probable variation of same due to low water, flood, or running conditions. Note.—For head on impulse wheels, see item (1) on "Impulse Wheels" (below).

(4) Reservoir.—If a reservoir is to be used in connection with the plant, its capacity, etc., in the case of intermittent load is important. A topographical plan of the site should be submitted so that calculations may be made as to the available "draw-down" capacity, etc. Also state whether the reservoir will be frozen over, so that storage capacity is lost.

(5) Pipe Line.—Send profile of existing or proposed pipe line. In case of existing line, give diameter; or, if of several sizes, give the length of each size. In the case of a proposed line, such a profile, showing the pressure at different points, is very essential to enable the size and thickness of the pipe to be economically chosen.

Water Wheels

(In addition to the above, the following data should be supplied.) Note.—"Overshot" wheels are here referred to; if other type is desired, it should be so stated.

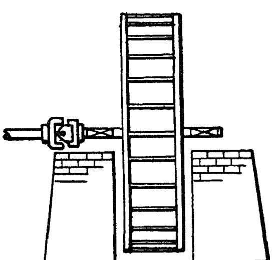


Fig. 27.—Water wheel arranged for slow-speed drive.

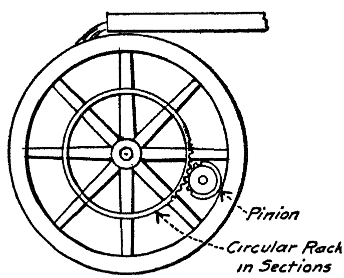


Fig. 28.—Water wheel arranged for high-speed drive.

(1) State horse-power desired and character of machinery to be driven. If the former is not known, give the size, capacity, speed, etc., of the machinery, so that a calculation may be made.

(2) Speed of shaft desired.
Note.—Wheels of 10 ft. diameter usually revolve at about 12 R.P.M.; 14 ft. diameter at 8 1/2, and 18 ft. diameter at about 6 1/2 R.P.M., and so on. If this speed is too slow for the service, a circular rack may be bolted to the side of the wheel operating a pinion; in this way speeds of the pinion shaft of 75 R.P.M. or more may be secured, see Fig. 28.

(3) State diameter of wheel desired.

(4) If the wheel-pit, head-race, etc., are already in place, send a sketch of same so that wheel may be constructed to suit.

(5) Is the wheel to be made entirely of iron; or of wood, with iron shaft, spiders, bolts, boxes, etc.

(6) Material to be supplied.
In the case of "all-iron" wheels, state specifically how much of the following material is to be furnished; wheel complete with shaft, pillow-blocks, flange (or universal) coupling for shaft, anchor-bolts for pillow-blocks, circular rack and pinion, pinion shaft (give length), bearings for pinion shaft.
In the case of wooden wheels, state also whether the wood-work of the wheel is to be furnished or only the bolts for assembling the same (from the manufacturer's drawings.)
(7) State whether material is to be supplied in sizes suitable for mule-back transportation.

Water Turbines

(In addition to the data called for under "General Data," the following information must be furnished.)

(1) State horse-power desired, maximum and minimum and character of machinery to be driven.
(2) Number of turbines or power units desired.
(3) Are units to be direct-connected?
Note.—In the case of electric generators (for example) the high speed generator is cheaper than the low speed for the same power and efficiency. But, if it is desired to connect directly to a turbine the higher speed will often necessitate the adoption of a turbine having a very low efficiency for that speed and power. It is best, therefore, to let the turbine manufacturer determine the speed in the first place and to then choose a generator to suit; the first cost may be somewhat greater but the efficiency of the plant will be higher.
(4) State whether geared or belted connections are preferred and give speed of driven shaft.
(5) State whether vertical or horizontal turbines are desired; and, if possible, send sketch showing general type of installation contemplated. (See Figs. 29 to 35)
(6) State revolutions of turbine shaft per minute, in case that it must be adhered to, see item (3) above.
(7) State how water is conducted from dam to turbines.
(8) Are turbines to run in open or closed penstock?
(9) Are turbines to be placed in an old plant?
(10) Is automatic regulation desirable?
(11) Material to be supplied. State specifically how much of the following material is to be supplied.
For Open Setting.—Turbine complete with draft tube, shaft coupling and (for horizontal settings) pillow blocks and stands; extension shaft with bearings; gearing and harness; pulleys (belt or rope); stuffing box (for horizontal setting); trash racks; head-gate hoisting apparatus; automatic regulator.
For Closed Setting.—Turbine complete with (extended) sub-base, shaft coupling, and pillow blocks and stands; extension shaft with bearings; pulleys (belt or rope); supply gate-valve; automatic regulator; any part of pipe line.
(12) State whether material is to be supplied in sizes suitable for mule-back transportation.

Impulse Wheels

(In addition to the data called for under "General Data" the following information must be furnished.)

(1) Head; the vertical head for impulse wheels is the vertical distance from head-water level to centre of nozzle.

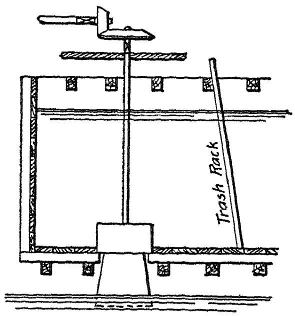


FIG. 29.—Vertical turbine in open setting for low head.

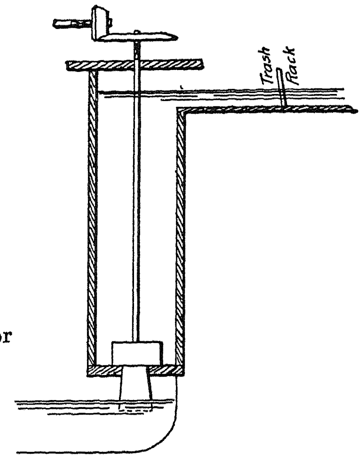


FIG. 30.—Vertical turbine in open setting for high head.

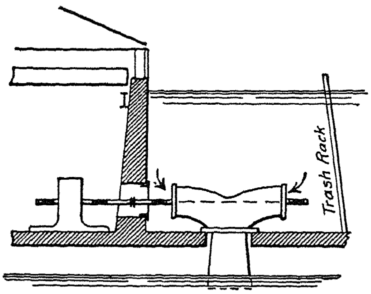


FIG. 31.—Horizontal turbine in open setting for low head.

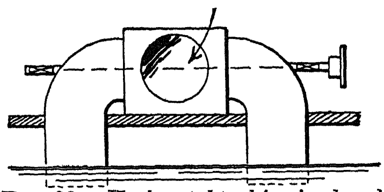


FIG. 32.—Horizontal turbine in closed setting for high head.

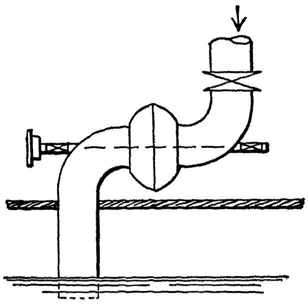


FIG. 33.—Horizontal turbine in closed setting for high head.

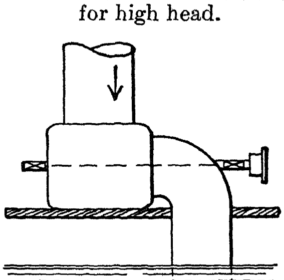


FIG. 34.—Horizontal turbine in closed setting for high head.

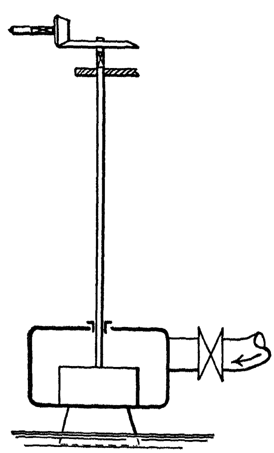


FIG. 35.—Vertical turbine in closed setting for high head.

(2) State horse-power desired, maximum and minimum, and character of machinery to be driven.
(3) Number of units required.
(4) If for driving an electric generator, state of what manufacture, speed, kilo-watt

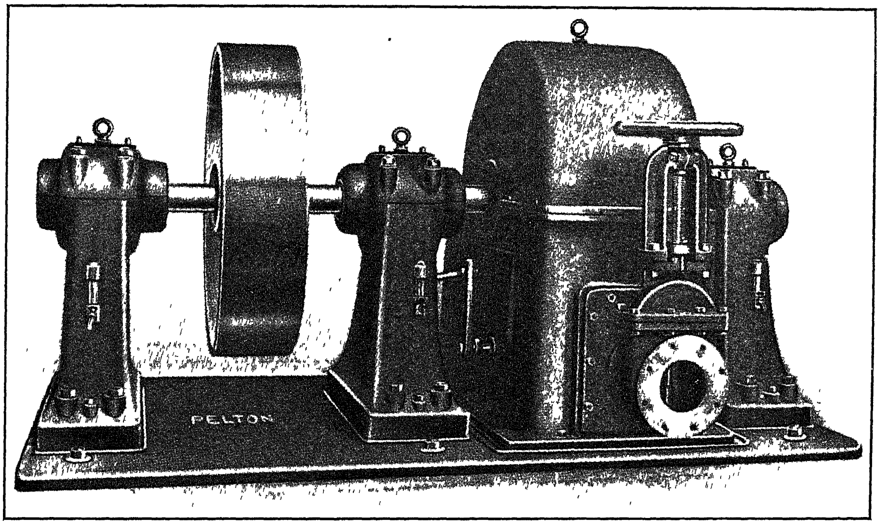


FIG. 36.—Pelton water wheel; iron mounted type.

capacity and style of shaft; also, if possible, send drawing so that sub-base may be designed.
(5) For other direct-connection drive, give speed required and size of shaft.
(6) For belted or rope drive, give speed and size of driven shaft and desired sizes (diameter and face) of both driven and driving pulley.

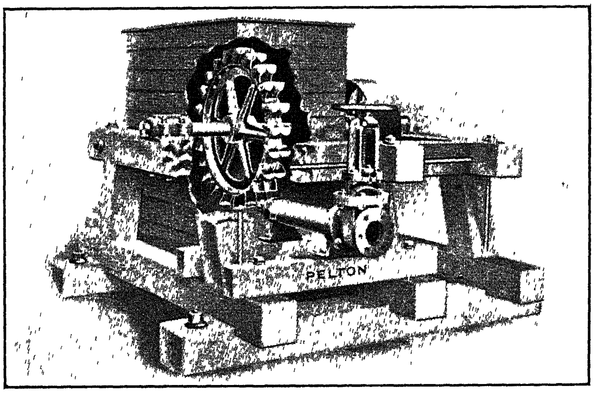


FIG. 37.—Standard Pelton wheel mounted on wood frame.

(7) State whether electric current is to be used for power transmission or lighting purposes, or both.
(8) If automatic regulation is desired, give the probable load variation and frequency of changes.

(9) What type of mounting is desired; timber frame, semi-masonry, or iron-mounted? See Figs. 36 to 38.

(10) Material to be supplied. State specifically how much of the following material is to be supplied:

For Timber Frame Mounting.—Wheel proper complete with buckets, shaft; pillow-blocks (3), two set collars, gate valve, rigid nozzle and nozzle tips; pulley and shaft coupling: also (special) deflecting nozzle; stream cut-off. needle nozzle; governor connections; taper nozzle and flange to main pipe. Framing-bolts and timber may be specified, but are usually procured and built at the site from drawings furnished by the wheel manufacturer.

For Semi-masonry Mounting.—Same material as above with the exception of

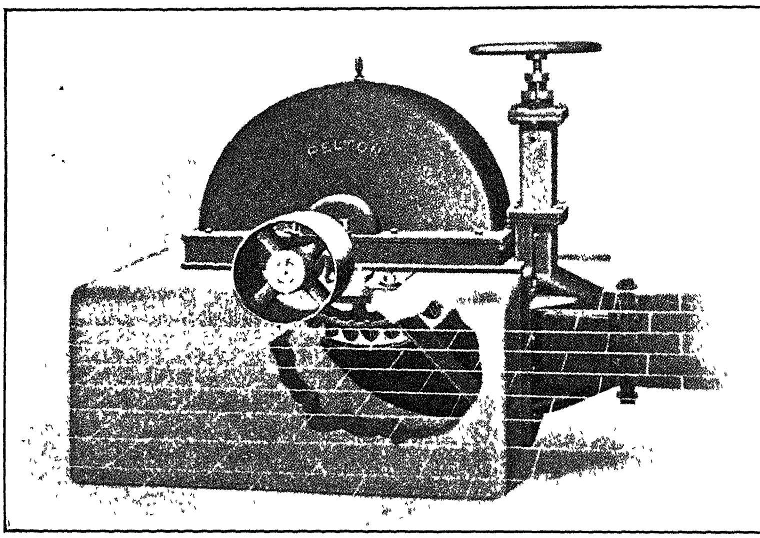


Fig. 38.—Pelton Quintex-nozzle wheel; semi-masonry mounted.

the timber and bolts, and add; sole plate and nozzle support, and cast-iron upper housing.

For Iron-mounted Type.—Same material as for timber frame mounting with the exception of the timber and bolts and add; upper and lower housings, floor-stands, and extended sub-base.

Pipe Line.—State what (if any) part of this is to be supplied.

(11) State whether material is to be supplied in sizes suitable for mule-back transportation.

Fans and Blowers

Blowing machinery may be divided into four classes, (1) the fan type, (2) the "positive" impeller or displacement type, (3) the piston or "blowing-engine" type and (4) special types, such as devices utilizing the fall of a column of water to compress entrapped air. Only the first two types are covered in the following "reminders," the other two do not offer apparatus of standard construction.

(1) **Service and Capacity**
State for which of the following services the blower will be required, and supply the data indicated.

(a) **General.**—If computed or otherwise known, give the volume of air to be handled, pressure at which it is to be delivered, suction pressure if any, and temperature. State whether blower is to be run for short periods, or continuously over several hours or days.

(b) **Foundry Cupola.**—Give the number of cupolas, diameter inside of lining, number and size of tuyères, and pounds of iron to be melted per hour.

(c) **Blacksmith Forges.**—State the number of forges and the kind of work they are engaged on.

(d) **Fuel-oil Burning.**—Give number of burners and pressure.

(e) **Gas Fires.**—Give number of burners and size of air tubes.

(f) **Ventilating Rooms.**—Give dimensions of room or rooms; state whether the fan is to be placed in wall or ceiling; state temperature of air to be exhausted, or describe use to which rooms are put. For disk fans to be built into walls, give thickness of wall so that flanges may be spaced to suit.

(g) **Larger Ventilating Systems.**—The system of ventilation should be planned by a competent ventilating engineer. In case such information has not been obtained and it is desired that designs and proposals be submitted by the contractors (an expensive method of obtaining the same), plans of the building should be given, showing all windows, doors, stairways, elevator shafts, etc., together with a complete statement of the conditions and requirements.

(h) **Mine Ventilating.**—The requirements must be submitted by a mining engineer.

(i) **Mechanical Draft for Steam Boilers.**—State whether forced or induced draft apparatus is desired; give number, horse-power, make and style of boilers, steam pressure and number in use at one time; diameter and height of stack and data as to draft carried or desired; if flues are long or constricted, describe same or send drawings; kind of fuel used, cost and quantity in long/short tons used per hour or 24 hours; feed temperature; how damper is controlled; number, kind and size of grates; air space; send sketch of boiler layout showing space available for blower.

(j) **Exhaust Systems.**—State what fans are to be used for, and amount of work they are expected to do. If for shavings or dust from machines, give the number and kind of machines, distance from the machine to the exhausts, and also distance the material is to be carried from the exhauster to receiving vault. State if for long shavings or stringy material. If for dry kilns, give capacity of kiln.

(k) **Hot Blast Apparatus.**—State what it is to be used for. If for heating or ventilating see (g) above. If for drying, give kind of material and quantity to be dried in given time.

(2) **Method of Driving**
State which of the following methods of driving is to be used, and supply the data indicated.

(a) **Belt Drive.**—If the driving engine, shaft, etc., is already in place or decided upon, give the R.P.M. of the shaft and also, if in place or arbitrarily fixed, give the diameter and face of the driving pulley.

(b) **Silent Chain Drive.**—Follow (a) giving, if decided, data as to chain to be used.

(c) **Direct-connection to Engine** (or steam turbine). If engine is not to be supplied with blower, submit drawing to blower contractor so that extended

bed, etc., may be constructed to suit, and state the R.P.M. If engine is to be supplied with blower follow "reminders" on p. 133.

(d) **Direct Connection to Motor.**—If motor is not to be supplied with blower, submit drawing to blower contractor so that extended bed, etc., may be constructed to suit, and state the R.P.M. If motor is to be supplied with blower follow "reminders" on p. 147.

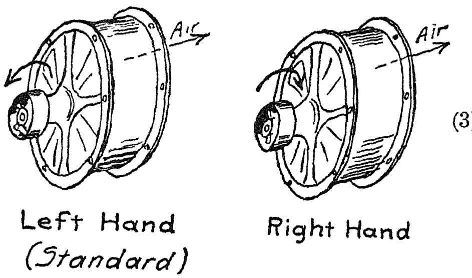


FIG. 39.—"Hand" of disk fans.

(3) **Type of Blower Desired**

State which of the following types of blowers is required or preferred.

(a) Wall Fan.
(b) Ceiling Fan.
(c) Full Housing Fan (most common type).
(d) Three Quarter Housing Fan.
(e) Wood Housing Fan.
(f) Brick Housing Fan.
(g) Positive Blower with Radial impellers.
(h) Positive Blower with Intermeshing impellers.
(i) Multiblade Fan ("Sirocco").

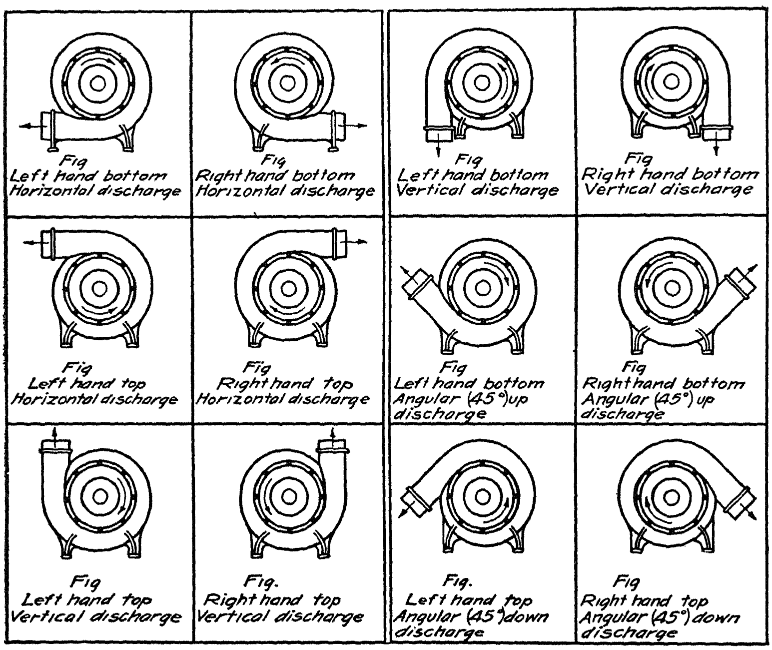


FIG. 40.—Hand and position of blowers; all views from pulley side.

(4) **Hand and Position**

(a) **For Disk Fans**

State hand as shown in Fig. 39.

(b) **For Centrifugal Fans**
The terms "Right Hand" and "Left Hand" as referring to the "position" of the discharge outlet of fans, are applied differently by the various makers, but the notation given in the figure seems the most logical.
A sketch such as is shown in Fig. 40 should, therefore, accompany the inquiry or order. Note that the direction of rotation of the fan is fixed by the position of the outlet; it can readily be determined by remembering that the air leaving the opening comes off at a tangent to the rotating rim, or is thrown off, as it were, by centrifugal force. *All views are shown from pulley side.*

(c) **For Positive Blowers, Radial Type**
Discharge is usually vertical; if a special arrangement is desired, send sketch.

(d) **For Positive Blowers, Impeller Type**
These blowers are built in two types, the vertical and the horizontal, but manufacturers have standard patterns which cannot well be altered. It is not always possible, therefore, to stipulate the type, but a preference may be indicated when calling for bids.

(5) **Material to be Supplied**
For the type of blower desired, state what items are to be furnished and also what are *not* to be furnished.

(a) **Disk Fans**
Fan with shaft; frame complete; wall bolts; pulley; pinion; coupling (flexible or flange); engine (see p. 133), steam turbine, or motor (see p. 147).
"Skeleton" fans consist of fan wheel, shaft, pulley and two journals, suitable for building into brick or other housing.

(b) **Centrifugal Fans**
Fan with shaft and boxes; housing; anchor-bolts; pulley pinion; coupling (flexible or flange); engine (see p. 133), steam turbine, or motor (see p. 147); extended base; blast gate.

(c) **Positive Blowers**
Blower complete; anchor-bolts; pulley; pinion; coupling (flexible or flange); engine (see p. 133), steam turbine or motor (see p. 147); extended base; companion flanges on suction and discharge; blast gate.

(6) **Number of Units Required**

Gas, Gasoline, Alcohol, Crude Oil, Etc., Engines

(1) **Fuel to be used**
(a) Natural Gas.
(b) Artificial Gas (coal-gas, water-gas, etc.).
(c) Producer Gas; describe fuel used, method of manufacture, and B.T.U. per 1,000 ft.
(d) Gasoline.
(e) Alcohol.
(f) Kerosene.
(g) Crude Oil. State whether of Petroleum or Asphalt Base (or, field from which obtained); and density in degrees Beaumé (or weight per cubic foot).
(h) Distillate.

(2) **Service.**—State in a general way the service the engine will have to perform; *i.e.,* whether operating a machine-shop, pumping, generating electricity for

lighting or power, etc., so that an idea may be obtained as to the regulation required, shocks to be withstood, etc.

(3) **Type of Engine Desired**
Stationary, Portable, Marine, Automobile.
Horizontal or Vertical.

(4) **Power**
State (Brake) Horse-power required, or give full conditions of work to be done so that size can be figured.

(5) **General Arrangement**
State whether engine is to be belt connected, or direct-connected through a friction-clutch or flange-coupling, etc. If for direct-connection to an electric generator, information should be given as for a high-speed steam engine (see p. 111.)

(6) **Speed, and Size of Pulley**
If not already indicated, give speed of engine required and size (diameter and face) of pulley or band-wheel.

(7) **Material Required**
State specifically those of the following items that are to be furnished with the engine.

(a) With Gas Engine;
Engine with flywheels.
Pulley.
Gasometer.
Muffler.
All oil cups.
Battery cells, cut-out, wiring, etc., complete.
Wrenches.
Foundation drawing and instructions for erecting, and see "Extras."

(b) With Gasoline Engine;
Same as for Gas Engine above, except omit Gasometer, and add:
Gasoline Pump.
Atomizer.
Gasoline Tank.

(c) With Kerosene and Crude Oil Engine; Same as for Gas Engine above, except omit Gasometer and Battery cells and wiring, and add; Ignition Outfit complete, and Fuel Tank.

(d) **Extras**
Water Tanks.
Air Reservoir with safety valve and pressure gauge, Air Pump and Starting Valve.

Note.—For engines up to 40 H. P. no compressed-air starting device is necessary; above this, up to about 60 H. P., it is a convenience but not a necessity.

Extended Bed, etc, for generator connection, see (5).
Friction-clutch with stand and lever for connection to pump, etc., shafts.
Foundation Bolts.

Gas Producers

(1) Describe very completely the **kind of Fuel** that will be used, submitting, if possible, an analysis of the same.

Note.—This should give the percentages of fixed carbon, volatile matter, ash and sulphur, and the calorific power.

In case fuel proposed is unusual, a sample of the same should be submitted (see p. 296).

(2) Describe the **Purpose** for which the gas is to be used.

Note.—The uses of producer gas may be classified under the following headings:

(a) Furnace Work, such as for heating slabs, blooms, plates, glass, etc., where the crude gas is used direct from the producer without having passed through scrubbers or washers.

(b) Other heating work, such as for cooking, coffee roasting, small furnaces, etc., where the gas is burned in small burners after being cleaned and cooled.

(c) Engine work, for which use, more especially, the gas must be clean and cool.

(3) **Capacity** required? Describe completely, giving amounts of material, number and size of furnaces, horse-power of engine, etc., etc.

(4) If the plant is to be installed in a given location, send a sketch of the **space available.**

(5) What material is available for use in the scrubbers, coke, sawdust, etc.? If other than coke, describe in sufficient detail.

Ice-making and Refrigerating Machinery

(1) For what purpose is the plant intended, ice-making, refrigerating, water-cooling, combined ice-making and refrigerating, or other use?

(2) Power; is the plant to be operated by steam engine, electric motor, gas-engine, or power from line shaft, etc.? If the motive power is to be furnished, give all information as to steam pressure, back pressure or vacuum; kind of electric current, voltage, phase and frequency, etc , as the case may be.

(3) Quantity and summer temperature of water and source of supply, for both condensing and ice-making purposes.

Ice-making Plants

Note.—The ice-making capacity of a machine is rated at the number of tons (of 2,000 lb.) of ice it will produce in 24 hours.

(4) Is "can" ice to be made, using the "brine" system, or "plate" ice, using the "direct-expansion" system?

(5) How many pounds of ice are to be produced per day, and is the plant to be in operation 10, 12 or 24 hours to produce this amount?

(6) Will natural water be used for making the ice, or must a distilling and purifying apparatus (using the exhaust steam from the engine) be supplied?

(7) What size of ice cake is preferred?

Note.—The usual sizes are about 10-, 20-, 60-, 100-, 150-, 200-, 300- and 400-lb. cakes.

Refrigerating Plants

(8) Describe fully the service for which the plant is intended.

(9) Capacity.—If the cooling rooms are not yet built and their size is not determined, state the quantity of meats, etc., to be cooled and stored, and the output per day of the product, so that an estimate can be made of the amount of room to be figured on. If existing rooms are to be cooled give their dimensions, use, output of product per day and character and efficiency of insulation.

(10) System.—Is the "brine" system or the "direct expansion" system of cooling pipes preferred?

Note.[1]—In the brine system the large body of chilled brine contained in the brine tank and pipe coils is a storage for cold, and is a reserve that can be used to maintain the temperature desired in the rooms for a considerable length of time by merely operating the brine circulating pump; it frequently being only necessary to operate the compressor during the day to maintain the temperature during the entire 24 hours.

In the direct expansion system the ammonia expansion coils are placed directly in the rooms to be cooled—only one system of pipes being required. The expense of the outfit is very materially reduced as compared with the brine system; the brine tank, brine pump, and secondary system of pipes for brine circulation being dispensed with, and a somewhat greater efficiency is obtained. In the direct expansion system the refrigerating effect ceases upon the stoppage of the compressor, and in small plants where this system is used and it is not desired to operate the machinery but a portion of each day, one or more brine storage tanks (in which a portion of the expansion coils are placed) can be installed in the cold storage room. The brine being cooled to a low temperature while the machine is in operation, this body of cold brine will help maintain the temperature during the time the machine is shut down.

Water Cooling Plants

(11) Describe the service, stating whether water will be used for domestic or manufacturing purposes, etc.

(12) Number of U. S. gallons of water to be cooled per hour, or number of drinking fountains to be supplied?

(13) Temperature of in-coming water?

(14) Is the water-circulating pump to be supplied with the outfit?

Material to be Supplied.

(15) State what parts of the following list of equipment is to be supplied by the ice-machine contractor, and what parts he is *not* to supply; ammonia compressor; prime-mover (steam engine, gas engine, motor, etc.); ammonia condenser, receiver, oil separator and all other special equipment of the ammonia system; freezing tank (steel plate work only); freezing tank cover complete; ammonia expansion coils; brine pump; brine piping; ammonia connecting piping; ice cans; can filler; can hoisting apparatus; can dump; special equipment for the plate or block ice system; fore-cooler; distilling and purifying apparatus complete (for making clear water); an initial (and spare) charge of ammonia; belting; and the following material (which is *not* usually supplied); boiler-plant; insulating material for freezing tanks; wooden freezing tank for the "plate" system; insulating material for the storage rooms; insulation for pipe mains; steam and water piping.

Hand Power Overhead Traveling Crane

Much of the information called for below can best be submitted on a sketch similar to Fig. 41. However, if the data indicated is supplied, bidders will have no difficulty in quoting, and will submit their own dimension sheets for the purchaser to check.

Principal Dimensions

Capacity in pounds; carried on one or two trolleys?

Span (centre to centre of crane rails).

[1] Extracted from Cat. "G" of the Remington Machine Co.

Lift (maximum vertical travel of hook).
Distance from (operating or working) floor to top of rail.
Lowest and highest points of hook from floor; compare "Lift" above.
Clearances.—Side (centre of rail to face of column or wall); Overhead (top of rail to lowest point of roof-truss); Knee-brace (send sketch); End (end of building to centre of hook); under (distance to lowest point of crane-girder; any line-shaft flywheels, locomotives, etc., to clear? Cage (centre-line of rail to inside face of cage, and under clearance).
Horizontal travel of hook; distance from centre of rail to centre-line of hook when at extreme position, for each side.
Runway Rail Section.
Kind of work.

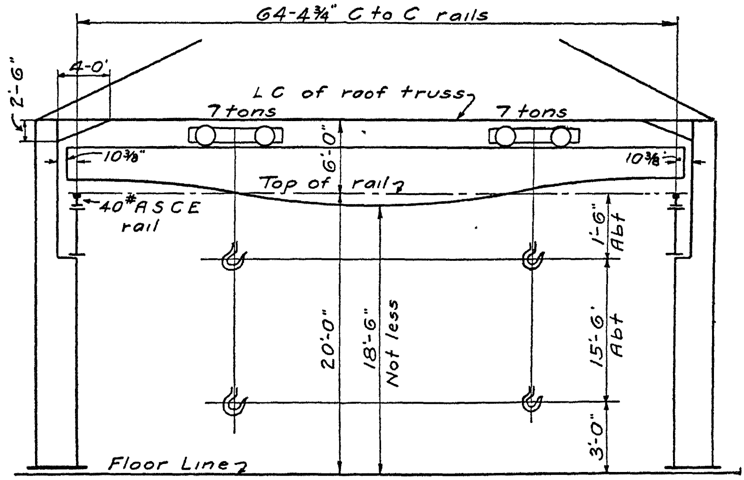


FIG. 41.—Typical dimension sheet for hand-power O. T. Crane.

General Arrangement

Hoist.—To be operated by chains from floor (self-contained hoist trolley, or separate differential, triplex or other blocks); by hand-winch on trolley (involving working gangways on bridge); by hand-winch in suspended cage; or otherwise.
Trolley Traverse.—To be operated by chains from floor; by hand-winch on trolley; by hand-winch in suspended cage; or otherwise.
Bridge Traverse.—To be operated by chains from floor (give location), by hand-winch above, by hand-winch in suspended cage, or otherwise.
Cage.—If required locate in plan on sketch.
Outdoor Service.—State if required so that covering may be provided for trolley, cage, etc.
Preferences as to chain or wire-rope for hoist.

Strength

Bridge; maximum allowable tensile and compressive stresses for flanges, deflection, shear in webs, stiffeners, rivet stresses, etc., for the dead load in conjunction with the critical position of the rated live load.
Trolleys and End-carriages; same considerations as above.
Hoist: rope or chain stresses allowable.
Factor of Safety; least for any part.

Electric Overhead Traveling Crane

A dimension sketch as shown in Fig. 42 should be supplied when asking for bids. Much of the information called for below may with advantage be placed on the sketch.

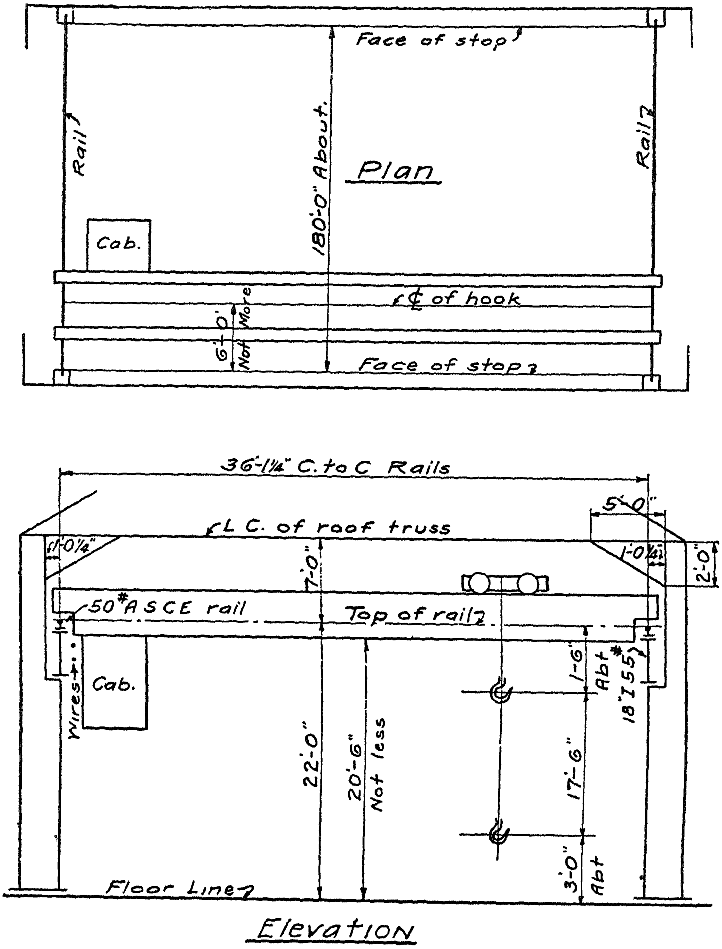


FIG. 42.—Typical dimension sheet for E. O. T. Crane.

Principal Dimensions

Capacity in pounds; for main and for auxiliary hoist (if any) or for two equal-capacity trolleys.
Span (centre to centre of crane rails).
Lift (maximum vertical travel of hook).
Distance from floor to top of rail.
Lowest and highest points of hook from floor; compare "Lift" above.
Clearances.—Side (centre of rail to face of column or wall; overhead (top of

rail to lowest point of roof-truss); knee-brace (send sketch); end (end of building to centre of hook); under (distance to lowest point of crane-girder; any line-shaft, flywheels, locomotives, etc., to clear?); cage (centre-line of rail to inside face of cage, and under clearance).
Horizontal travel of hook; distance from centre of rail to centre line of hook when at extreme positions, for each side.
Runway Rail Section.
Length of runway.
Service, or class of work.

Motors and Speeds
Current available; if Direct, give voltage (of constant-potential circuit); if Alternating, give number of phases, frequency and voltage.
Type of Motors desired.
Hoist Motor(s); speed at which full load (main and auxiliary) is to be lifted.
Trolley Traverse Motor; speed at which full load is to be traversed.
Bridge Traverse Motor; speed of crane on runway with full load.

Miscellaneous
Cage; locate in plan on sketch.
Wires; if in place, locate on sketch.
Outdoor Service; state if required, so that covering may be provided for trolley, cage, etc.
Preferences as to chain or wire for hoist; type of controllers.

Strength
Bridge; maximum allowable tensile and compressive stresses for flanges, deflection, shear in webs, stiffeners, rivet stresses, etc., for the dead load in conjunction with the critical position of the rated live load.
Trolleys and End-carriages; same considerations as above.
Hoists: rope and chain stresses allowable.
Factor of Safety; least for any part.

Steam Locomotive

The following schedule covers the data that should be submitted to the manufacturers when calling for bids or placing an order. In the event that the type of engine, size of cylinders, steam pressure, etc., are already determined, the items referring to Traffic Conditions may be omitted; or *vice versa* the Principal Dimension items may be omitted and the Traffic Conditions be given: if there is any doubt as to the size required, both headings may be filled out and the proper caution added.

Track Conditions
(1) Gauge of track (*i.e.*, space inside of rail heads).
(2) Weight of rail per yard.
(3) Maximum clearance vertically (height above top of rail).
(4) Maximum clearance laterally (allowable width).
(5) Submit a "Clearance diagram" if possible (see Figs. 109 to 113).
(6) Length of road.
(7) Maximum grade, and length of same.
(8) Maximum curvature.
(9) Does grade occur on a curve?
(10) If so, is grade compensated for curvature?

Traffic Conditions

(11) Kind of traffic.
(12) No. of coaches and weight in average train in tons of 2,240/2,000 lb.
(13) Ditto for heaviest train.
(14) Is heaviest train to operate on heaviest grade?
(15) Will train have to start on a grade?
(16) State number of speeds desired. State combination of speeds desired?
(17) For which loading is the engine to be especially designed?

Fuel and Water

(18) Kind of fuel: anthracite or bituminous coal, coke, lignite, wood (give kind), oil (describe fully), etc.
(19) Kind of water; is water badly scale-producing, so that extra hand-holes, etc., must be provided?

Principal Dimensions

(Note.—These items should not be filled in unless absolutely known or decided upon.)
(20) Diameter and stroke of cylinders (H.P. and L.P.)
(21) Class of engine required (see System in Fig. 244).
(22) Boiler Steam Pressure.
(23) Diameter of Driving Wheels.
(24) Heating Surface of Boiler.
(25) Grate Area.
(26) Water Storage Capacity.
(27) Fuel Storage Capacity.

Draft Gear

(Note.—It is imperatively necessary that this information be submitted when placing an order).
(28) Style of drawbars, drawhooks or couplers (send sketch if possible).
(29) Height above rail (to centre) of drawbars, drawhooks or couplers.
(30) Location of buffers, whether located centrally or at sides.
(31) If buffers are located at sides, state distance apart centre to centre.
(32) Height above rail to centre of buffers.
(33) Style of couplers.

Details of Construction

(34) Firebox to be of steel or copper?
(35) Tubes of charcoal iron, seamless-drawn steel, copper or brass?
(36) Grate; state any special requirement.
(37) Smoke Stack; straight, diamond or special?
(38) Valves and Valve Motion; state any special requirements.
(39) Cab; state any special requirements.
(40) Pilot; "Cowcatcher" or step? Is either required on rear end?
(41) Headlight; One or two? Oil, acetylene or electric?
(42) Engine Brakes; steam or air?

Finish

(43) State any special coloring or finish desired.
(44) Name(s) and Number(s); where placed, style desired.

Special

(45) Train Brakes: required or not? Westinghouse or other type?
(46) Are screw-threads to be other than U. S. standard?

Railroad and Industrial Cars

(1) Gauge of track (distance inside of rail heads).
(2) Weight of rail on which cars run.
(3) Radius and length of sharpest curve.
(4) Style of car required: four-wheel platform car, flat car, gondola, box, sugar cane, logging, tank, dump or special; describe as fully as possible, sending sketch.
(5) Material to be handled and its weight per cubic foot.
(6) Capacity of each car, in tons of material, or cubic feet, or number of pieces, etc.
(7) If possible, give main dimensions, such as length inside or over end sills, width inside or over side sills, height of body or of stakes above floor, distance from top of rail to floor.
(8) Are there any limitations (due to tunnels, yard clearances, etc.) as to height, width or length? Send sketch.
(9) Style of coupling or drawbar; automatic, link and pin, etc. When placing order with a firm who has not the information, a detail drawing must always be sent.
(10) Give distance from top of rail to centre of coupling.
(11) Are cars to be operated by hand, animals, steam or electricity?
(12) Are cars to be operated singly or in trains? If the latter, state number of cars to a train.
(13) Give dimensions of wheels and axles already in use (as per sketch on p. 187) if new cars are to be used with old ones.
(14) Style of axle boxes, if inside or outside, roller bearings, etc., if with or without springs.
(15) Are there any other points to be considered? If so, please state and make any further remarks in regard to cars.
(16) What kind and color of paint is to be used to paint cars? Give numbers and lettering required.

Locomotive Crane

(1) Gauge of track?
(2) Class of work that crane will be engaged on? Special requirements?
(3) State the maximum load to be carried and swung without out-riggers and at what maximum radius.
(4) State the maximum radius to be reached and the corresponding load when the outriggers are placed.
(5) Are heavier loads to be carried at shorter radii? Give particulars.
(6) At what minimum radius are loads to be placed?
(7) At what speeds is the crane to operate? Describe the operation.
(8) What is the radius of the shortest curve over which the crane will operate?
(9) Are there any special clearance requirements in the yard, at sides or overhead?
(10) What kind of coal will be used?
(11) Will crane be used to switch cars? How many cars and at what speed?
(12) Style of coupler to be fitted? Height to centre-line?
(13) Is an air brake to be fitted? (For coupling to a freight train for hauling over road).
(14) Is crane to be fully housed?
(15) Is a (Clam Shell) bucket to be supplied?
(16) How is crane to be shipped?

Hoisting Engine for Haulage, Etc.

Note.—For outline of ordering requirements for ordinary hoisting engines, see p. 179.

(1) **Service.**—State whether for hauling cars on inclines, for shafts, cableways, coaling-towers, etc.; how many ropes are to be operated and in what manner, material hoisted, etc.

(2) **Capacity.**—State either, (1) the load to be raised, the speed, the slope of the incline, and the character of the cars and the track so that a calculation can be made as to the power required, or, (2) the pull on each line and the speed required.

Also state the diameter and length of rope to be wound on each drum; material of the rope; number and diameter of sheaves the rope runs over between the load and the drum and the arrangement of same.

(3) **Style.**—State whether a single or a double drum is required, and whether the latter are to be entirely independent or operated by a central gear with brake control. Reversible or non-reversible?

(4) **Power.**—Steam or Electric?

For Steam Power state steam pressure available at the throttle, and whether there is any vacuum or back pressure and how much?

For Electric Power state whether current is direct or alternating: if the former give the voltage, and if the latter give the voltage, phase and frequency.

(5) **Number of Units Required?**

(6) **Material to be Supplied.**

State which of the following items are to be supplied and which are *not* to be supplied:

Steam Power; hoist complete with all necessary oil cups, wrenches, sight-feed lubricator, drain-cocks, steam connections to and including throttle-valve, anchor bolts, and indicator (for showing location of car). Also state whether a boiler is required, and whether it is to be attached to hoist or mounted separately.

Electric Power; hoist complete with all necessary oil cups, wrenches, anchor bolts, indicator (for showing location of car), motor, controller, and solenoid (electric) brake.

(7) **Spares.**—State whether any spare parts are to be supplied (enumerate, or call for recommended list).

(8) **Shipping.**—State whether there are any limitations on weights of pieces as affected by shipping facilities.

Foundry Cupola

(1) **Number of Units Required**

(2) **State class of work to be used on, whether**

- (a) General foundry work (machine, architectural or jobbing).
- (b) Light work (stove, agricultural, radiator, malleable, etc.).
- (c) Heavy work (pipe, car wheels, ingot molds and heavy machinery).
- (d) Bessemer work (steel plants, steel casting plants, etc.).
- (e) Testing (small heats, experimental work, etc.).
- (f) Bedstead (continuous melting).
- (g) Portable (cast-iron rail joints, etc.).

(3) **Size or Capacity**

The "size" of a cupola is the diameter of the steel stack (distance "D" in the sketch). The "capacity" is given as the weight of iron that can be melted in

1 hour, a very variable quantity.
State either the size or capacity desired.

(4) **Principal dimensions**
Give the following distances:
Total height of stack from foundation (F).
Height of Legs (H) if maker's standard is not acceptable.
(Note.—Doors must have room to swing clear)
Height of Charging Door (E).
Length of Tap Spout (J) and, of Slag Spout (K) if maker's standard is not acceptable.

(5) **General Arrangement**
(a) Is charging door to be placed over slag spout (usual arrangement) or otherwise?
(b) Locate on a plan view, similar to sketch, the desired position of blast nozzle.
(c) If roof hood is required give roof slope as shown.

(6) **Material to be Supplied**
State which of the following items are to be supplied:
(a) The furnace proper only (Part "A"), comprising inner and outer shells, tapping and slag spouts, bottom plate and drop doors, tuyères, etc., or,
(b) All the above and also part "B," legs and foundation-plate (or tie-rods), or,
(c) The cupola complete, *i.e*, parts "A," "B" and "C," the latter part including the stack and charging door.
(d) Spark Arrester.
(e) Roof Hood (give roof slope).
(f) Operator's Platform and Stairway to same (needed only when legs are very high).
(g) Blast Gauge.
(h) Brick lining (see p. 205).
(i) Fireclay (state amount).
(j) Blower (see p. 158).
(k) Blast Pipe and Fittings.

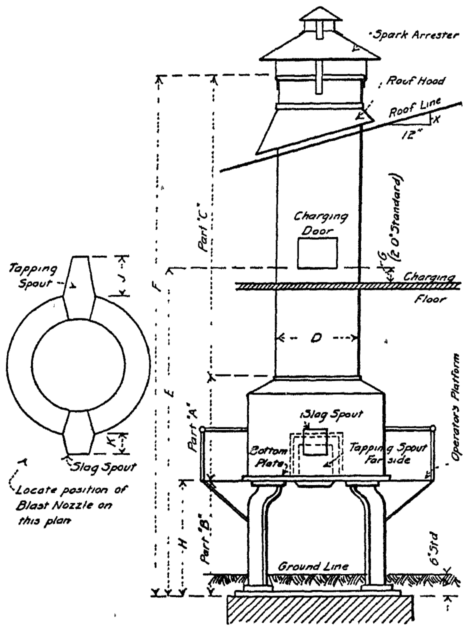


FIG. 43.—Foundry cupola.

(7) **Material not to be supplied.**
Enumerate such of the above as are not to be supplied.

SCALES

Warehouse Scales
(1) Portable or Fixed?
(2) Size of Platform? (Bidder to quote on nearest standard size.)

(3) Capacity, total and increment (*e.g.*, 3,500 × 1/2 lb.)?
(4) Any particular style of pillars, etc.?
(5) Also see items No. 22 to 25 inclusive.

Wagon Scales

(6) Size of Platform? (Bidder to quote on nearest standard size.)
(7) Capacity in pounds?
(8) Is beam to be any extra distance from edge of platform?
(9) Is the framing of the scale to be of wood or steel? The latter has greater durability and less cost in repair, and in tropical countries its use is often imperative on account of the ravages of insects, etc.
(10) Material Supplied. Note that the timber for the frame and platform are not regularly supplied, although a drawing for same accompanies the shipment. If this wood work is required, it should be so specified.
(11) Any special requirements?
(12) Also see Items No. 22 to 25 inclusive.

Railway Track Scales

(13) Gauge of Track?
(14) Length of Platform?
(15) Capacity in pounds?
(16) Is the framing of the scale to be of wood or steel? (See remarks of Item No. 9.)
(17) Is a by-pass to be provided for (to allow the locomotive or cars to pass the scale without straining the mechanism)?
(18) If not, will the locomotive pass over the platform? Give weight and style of locomotive.
(19) Material Supplied (See Item No. 10).
(20) Any special requirements; overhead suspension, etc.?
(21) Also see Items No. 22 to 25 inclusive.

General

(22) Are beams and weights to be graduated to English or Metric scale?
(23) Are beams to be of Single, Double, Triple, or Gridiron Type?
(24) Is beam to be of the Registering type (*i.e.*, with tickets)?
(25) Any special requirements for beams or weights?

Machine Tools

The following notes are intended both as aids for obtaining prices and placing orders for machine tools, and also as guides to the selection of a suitable machine. Only standard tools and attachments are considered.

Belt-driven Tools

Line shafts for machine-tool drives usually run at from 150 to 175 R.P.M., and the driven pulleys supplied with the tools are proportioned for these speeds. When laying-out and ordering line-shafting and driving pulleys, prints or cuts of the machines must be obtained, giving the speeds and sizes of pulleys on the countershafts, etc., of the tools, so that the diameter and face of the driving pulleys may be calculated. For belt-driven tools, therefore, it is unnecessary to give the bidders information concerning the drive, unless conditions are very special.

Electric-driven Tools

These are tools driven by an individual motor which is usually mounted on the machine and direct-connected to its mechanism. In some cases, however (with planers, for example), belts are used for the connection; any particular preference for the style of intermediate drive should be stated when obtaining quotations on these tools.

Also state kind of current and voltage, and, in case of alternating current, state also phase and frequency.

Also be sure to state *whether the motor is to be supplied or not.*

Engine Lathes

The nominal size gives approximately the diameter in inches of the largest piece that can be swung over the bed, and the length in feet of the bed over all. Thus, a "12-in. × 6-ft." lathe will take a piece 12 in. in diameter and has a bed 6 ft. long over all. Actually such a lathe will swing a piece about 13 1/2 in. in diameter over the bed and about 8 in. in diameter over the rest, while the maximum length of piece that can be taken in the centres will be about 3 ft. 8 in. These limitations are well understood by mechanics, however, and the nominal dimensions of "swing × length of bed" are universally used to designate sizes.

"Gap" lathes are constructed with a "gap" in the bed at the face-plate to accommodate flat pieces of large diameter. Their nominal size gives the approximate diameters of the material that can be swung over the top and bottom beds respectively, by the length of the bed. Thus, a "28-in. and 48-in. × 10-ft." lathe will swing 28 in. over the top and 48 in. over the lower bed, and the overall length of the bed (when closed) is 10 ft., with limitations as described above. "Extension gap" lathes have a top bed carried on guides or ways, which can be extended so as to take pieces between centres of almost double the length than when closed.

When obtaining quotations give:

(1) Nominal size; or capacity required as described above.
(2) Power; whether belt or electric drive.
(3) Service.
(4) Styles and Attachments required:
  Change gears, or with Quick Change gear device?
  Plain rest or compound rest?
  Elevating Rest; Taper Attachment?
  Single-pulley, all-geared Headstock; or Cone-driven?
  The following fittings (regularly supplied): steady rest, follower rest, large and small face plates, countershaft and all necessary wrenches.
  Other Fittings: face plate jaws, independent chuck, combination chuck, lathe tools.

Drill Presses

The nominal size of drill presses gives the diameter of the circle to the centre of which they will drill. The capacities of drills of the

same nominal size varies somewhat, but are generally well understood by mechanics.

When obtaining quotations give:

(1) Nominal size, and (if special) maximum height of piece to be taken (on base).
(2) Power; whether belt or electric drive.
(3) Styles and Attachment required:
Hand or power feed?
Tapping attachment?
With or without back gear?
Tilting table?
Taper arbor for drill spindle, sleeves for same, drill chuck, drills?
Note —For belt-driven tools there is no separate countershaft, the machine is belted direct to the line-shaft.

Radial Drills

The nominal size gives approximately the distance from face of column to centre of spindle at extreme position. They are designated as "Plain," "Half Universal" and "Full Universal." In the Full Universal the saddle swivels in a vertical plane, and the arm swivels also in a vertical plane at right-angles to the first, so that holes may be drilled at any angle. In the Half Universal either one, but not both swivels, and the inquiry should state which. In the Plain drill, neither saddle nor arm swivels and holes can be drilled in a vertical direction only.

When obtaining quotations, give:

(1) Nominal Size, and (if special) maximum height of piece to be taken (on base).
(2) Power; whether belt or electric drive.
(3) Service.
(4) Styles and Attachments required:
Plain, Half Universal or Full Universal (see above)?
Arm to be hand or power elevated?
Tapping attachment?
Side-table (for small work)?
Cone-pulley or speed-box drive?
Taper arbor for drill spindle, sleeves for same, drill chuck, drills.

Milling Machines

Sizes are nominal, but all makes of the same number have about the same capacity. Table II gives the average capacities of Plain, Universal and Vertical Spindle Milling Machines of the more usual sizes, the figures referring to the motions of the table. Thus, on a No. 3 Plain Milling Machine the table has an automatic longitudinal feed of 34 in., a hand or automatic transverse feed of 10 in., and a hand or automatic vertical feed of 20 in. In the case of the Vertical Spindle machines, the last figure gives the greatest distance from end of spindle to top of table. Hand machines are made in such great variety for special purposes, that it is necessary to describe in detail the work to be performed, as sizes do not mean much.

The principal types of milling machines are Hand, Plain, Universal and Vertical Spindle: there are also many variations and special types.

In Hand milling machines, the spindle is power-driven, but the horizontal and vertical movements of the table are effected by hand, usually by levers. In the Plain machine the table does not swivel (about a vertical axis), and the dividing-head and foot-stock centres (for gear-cutting, etc.) are not regularly supplied. In the Universal Machine the table swivels (about a vertical axis), and the dividing-head and foot-stock centres are furnished as part of the machine. The ordinary Vertical Spindle machine is similar to the Plain miller except that the spindle is vertical.

Table II.—Capacities of Milling Machines

Type	Nominal size			
	No 0	1	1½	2
Plain	18×6×15	24×7×19	24×7×19	28×8×19
Universal		20×7×18	20×7×18	25×8×18
Vertical . .	. ... .	28×12×20	.. ... .	28×13×22
	Nominal size			
	No. 2½	3	4	5
Plain .	28×8×19	34×10×20	42×12×20	50×12×21
Universal	25×8×18	30×10×19	35×12×20	. .
Vertical	.	34×13½×23	. .	52×12×24

For ordinary repair-shop work, the No. 3 Plain miller, with dividing-head and foot-stock attachment, is a convenient machine.

When obtaining quotations give:

(1) Nominal size, as described above.
(2) Type, as described above.
(3) Service.
(4) Power; whether belt or electric drive.
(5) Styles and Attachments required:
Dividing-head and foot-stock centres (see above), and universal chuck?
Single Pulley Drive (with all-gear reduction); or Cone Pulley Drive?
Hand or Automatic Transverse Feed?
Hand or Automatic Vertical Feed?
Vise; plain or swiveling base?
Oil Pump attachment complete?
Vertical Spindle attachment?
Rack Cutting and Spacing Attachment?
Circular Milling Attachment?
Universal Milling Attachment?
Etc., etc.
Tools.—Standard outfit of cutters, arbors, collets?
Countershaft, oil pot, and wrenches are regularly supplied. Also, with plain millers a vise is usually regularly supplied; and with universal machines, the dividing-head, etc., and a universal chuck, in addition to the above.

Planers

The nominal size of planers is usually given by three figures, the first giving the width in inches of the largest piece that can be carried between the housings, the second the maximum height in inches of the piece that can be taken under the head, and the third the length of the bed in feet.

Sometimes, however, only one figure is given; thus, a "42 in." planer means one which will take a piece 42 in. × 42 in., the length of the bed being understood to be of a size usual to this capacity. The length of cut that can be taken is the same as the nominal length of bed.

When obtaining quotations give:

(1) Nominal size, as described above.
(2) Power; whether belt or electric drive.
(3) Service.
(4) Styles and Attachments required:
One or two heads on cross rail?
Head on side rail? One or both sides?
Variable speed device?
Countershaft and wrenches are regularly supplied.
Other fittings:
Planer chuck, planer centres, planer tools, leveling jacks, angle block.

Shapers

The nominal size gives the maximum stroke of the machine.

Shapers are of two general styles, "crank" shapers, in which the motion is obtained from a crank and lever; and "shifting belt" or "rack" shapers, in which the motion is the same as in planers. The former has a positive length of stroke and will plane to an exact line, while the latter will not. "Crank" shapers are most usually supplied.

When obtaining quotations give:

(1) Nominal size as described above, or state requirements concerning size of pieces to be tooled, etc.
(2) Power; whether belt or electric drive.
(3) Styles and Attachments required:
Crank or Shifting Belt type (see above)
Countershaft, vise and wrenches are regularly supplied.
Other fittings:
Power down-feed, circular feed to head, revolving table, tilting table, shaper centres, cone arbors, concave attachment, mould maker's vise, shaper tools.

Boring Mills (Vertical)

The nominal size gives the diameter of the table, pieces 1 or 2 in. greater in diameter can usually be swung. The larger sizes are sometimes made "extension," carrying material of about 50 percent greater diameter.

When obtaining quotations give:

(1) Nominal size as described above; or give diameter (or swinging diameter) and height of largest piece to be handled, and a description of the work to be performed.
(2) Power; whether belt or electric drive.

(3) Styles and Attachments required:
Countershaft and wrenches are regularly supplied.
Other fittings:
Slotting attachment, boring bar, side grooving head, threading attachment, face-plate jaws.

Power Hack Saws

These are designated by the different makers as No. 1, No. 2, etc. In ordering it is best to specify the capacity, *i.e.*, the size of the largest bar to be cut. The usual capacities are as follows: No. 1, 4 in. × 4 in.; No. 2, 5 in. × 5 in.; No. 3, 5 in. × 6 in.; No. 4, 7 in. × 8 in. The machines are driven from the line-shaft direct without an intermediate countershaft, the motion being stopped and started by means of a clutch and lever on the machine. The larger machines can be obtained with swivel vises, so that cuts can be made at any angle.

Pipe Machines

These machines, used for threading and cutting pipe, usually bear arbitrary maker's numbers. When ordering, it is best to give the capacity. These run about as follows: 1/4 to 2 in.; 1/4 to 3 in.; 1 to 4 in., 1 1/2 to 6 in., 2 1/2 to 8 in., 2 1/2 to 10 in., 2 1/2 to 12 in., 7 to 16 in., the size in each case being the limiting sizes of pipe which can be cut or threaded.

When obtaining quotations give:

(1) Capacity as described above.
(2) Power, belt, direct-connected steam engine, direct-connected electric motor, combined hand and power (for either of above).
(3) Style and Attachments required:
One set of (right-hand) dies for American Standard "V" thread is regularly supplied; if dies for Whitworth Standard or other threads are required they should be specially ordered.
A countershaft, a cutting-off device and all wrenches are also regularly supplied.
Other fittings are rear pipe rest, oil pump, nipple holder, attachments for threading bolts and tapping nuts, and wheels for rendering machine portable.

Bolt Cutting Machines

The nominal size gives the size of the largest bolt that can be handled. They can be obtained in a wide variety of sizes and designs for special uses. Usual capacities are as follows: From 1/4 in. to 1/2 in., 3/4 in., 1 in. and 1 1/4 in.; from 1/2 in. to 1 1/2 in., 2 in., 2 1/4 in., 2 1/2 in. and 3 in.; from 3/4 in. to 2 1/4 in., 2 1/2 in., 3 in., and 3 1/2 in.; from 1 in. to 3 1/2 in., 4 in., 5 in., and 6 in.

Hand-driven machines may be obtained up to 1 1/2 in.

When obtaining quotations give:

(1) Capacity as described above.
(2) Power; belt, motor drive, combined hand and power (for either of above).
(3) Style and Attachments required:
The following attachments are regularly supplied; countershaft, wrenches, set of dies, set of taps, die head, tap chuck and chip and oil pans.
Other attachments are pipe dies, power feed and lead screw, and oil pump.

Punches and Shears

Single ended machines can be used for either punching or shearing by simply changing the dies. Double ended or "combined" machines can also be changed for either operation. The only reason that "combined" machines are built is because the design of these tools renders them well adapted to a cheap and compact combination; in other words, a machine of twice the capacity (output) can thus be obtained at somewhat less than twice the cost and floor space. A great number of variations in capacity and scope of operations can be obtained, so that in calling for prices the work that the machine is to perform should be described quite fully. The following table, giving the relative capacities of punches and shears as usually built, will serve as a guide in outlining capacities to the bidder.

Table III.—Capacities of Standard Vertical Punches and Shears, Applying to Either Single or Double Machines. All Dimensions in Inches

Punching capacity		Shearing capacity				Standard depth of throat
Diam. of hole	Thickness mate'l	Pl's	Rounds	Flats	Angles	
$\frac{5}{8}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{4}$	$3\frac{1}{2}\times\frac{1}{4}$	$1\frac{1}{2}\times1\frac{1}{2}\times\frac{1}{8}$	25, 20
$\frac{5}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{7}{8}$	$3\frac{1}{2}\times\frac{3}{8}$	$1\frac{1}{2}\times\frac{1}{2}\times\frac{3}{16}$	36, 30, 25, 20, 12
$\frac{3}{4}$	$\frac{3}{8}$	$\frac{3}{8}$	1	$3\frac{1}{2}\times\frac{1}{2}$	$1\frac{1}{2}\times1\frac{1}{2}\times\frac{1}{4}$	36, 25, 20, 16, 5
$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$1\frac{1}{8}$	$4\times\frac{1}{2}$	$2\times2\times\frac{1}{4}$	42, 36, 30, 25, 20, 12
$\frac{7}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$1\frac{1}{4}$	$4\times\frac{5}{8}$	$2\frac{1}{2}\times2\frac{1}{2}\times\frac{1}{4}$	60, 54, 42, 36, 30, 25, 20, 6
1	$\frac{5}{8}$	$\frac{5}{8}$	$1\frac{3}{8}$	$5\times\frac{5}{8}$	$3\times3\times\frac{1}{4}$	60, 54, 48, 30, 25, 20, 12, 7
1	$\frac{3}{4}$	$\frac{3}{4}$	$1\frac{1}{2}$	$6\times\frac{3}{4}$	$3\times3\times\frac{5}{16}$	60, 54, 48, 42, 36, 25, 20
1	$\frac{7}{8}$	$\frac{7}{8}$	$1\frac{5}{8}$	$6\times\frac{7}{8}$	$3\frac{1}{2}\times3\frac{1}{2}\times\frac{5}{16}$	60, 54, 42, 30, 20, 12
1	1	1	$1\frac{3}{4}$	6×1	$4\times4\times\frac{5}{16}$	60, 48, 36, 30, 25
$1\frac{1}{4}$	1	1	$1\frac{7}{8}$	$6\times1\frac{1}{8}$	$4\times4\times\frac{3}{8}$	72, 60, 54, 48, 42, 36, 25, 20, 15
$1\frac{1}{2}$	1	1	2	$6\times1\frac{1}{4}$	$4\times4\times\frac{1}{2}$	72, 66, 60, 54, 48, 42, 36, 30
$1\frac{1}{2}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$2\frac{1}{8}$	$6\times1\frac{1}{2}$	$5\times5\times\frac{3}{8}$	72, 66, 54, 48, 42, 36, 30, 25, 20
$1\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$2\frac{1}{4}$	$7\times1\frac{1}{2}$	$5\times5\times\frac{1}{2}$	72, 66, 60, 48, 36, 30, 25, 20, 12
2	$1\frac{1}{4}$	$1\frac{1}{4}$	$2\frac{1}{2}$	$8\times1\frac{1}{2}$	$5\times5\times\frac{5}{8}$	66, 60, 54, 48, 42, 36, 30, 25, 20, 14
$2\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{1}{4}$	$2\frac{3}{4}$	$10\times1\frac{3}{8}$	$6\times6\times\frac{1}{2}$	60, 54, 48, 42, 36, 30, 25
$2\frac{3}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	3	$10\times1\frac{1}{2}$	$6\times6\times\frac{5}{8}$	72, 60, 54, 48, 42, 36, 30, 15
$2\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$3\frac{1}{4}$	$10\times1\frac{3}{4}$	$6\times6\times\frac{3}{4}$	72, 60, 48, 36, 30, 25
3	$1\frac{1}{2}$	$1\frac{3}{4}$	$3\frac{1}{2}$	10×2	$6\times6\times1$	36, 18
3	2	$2\frac{1}{4}$	$4\frac{1}{2}$	$10\times2\frac{1}{2}$	$8\times8\times1$	36, 18
4	2	$2\frac{1}{2}$	$5\frac{1}{2}$	12×3	$8\times8\times1\frac{1}{2}$	18

The punching capacities in the above table may be used as a basis for determining the rating of the machines on holes of different diameters and through different thicknesses.

When obtaining quotations give:

(1) Capacity and depth of throat of machine as indicated above.
(2) Power; belt, steam-engine or motor drive.
(3) Style and Attachments required:
Single or double ended? The following equipment is regularly supplied; one pair of shears, one punch and die with the necessary connections and the usual gauges, stripper and wrenches.

Other attachments are special shears, dies, gauge dies, blades for rounds, angle shears, architectural jaw, automatic stop, radial crane (for attachment on top of machine), etc.

Steam Hammers

There are two general styles of hammers, single frame and double frame. The smaller sizes are usually of the former type, and, having only one pedestal and being approachable from all other sides, they are well adapted to general blacksmith-shop work. The double frame type, having two pedestals, can be designed for the largest sizes, and is better adapted to heavy, special work.

The various sizes are designated by the actual weight of the ram with its die and rod and piston; the added force of the blow from the steam or air pressure on top of the piston is not taken into consideration. The following sizes are typical for single frame hammers:

Size, pounds	Stroke	Size, pounds	Stroke
200	16 in.	2,000	36 in.
250	16 in.	2,500	39 in.
400	19 in.	3,000	42 in.
600	22 in.	3,300	42 in.
800	25 in.	3,500	45 in.
1,100	28 in.	4,000	42 in.
1,250	30 in.	4,500	42 in.
1,500	33 in.	5,000	48 in.

The following table will be found convenient for reference when determining the proper size of hammer to be used on the different classes of general blacksmith work. The smaller hammer will be large enough in case the size of stock is only worked occasionally, while the larger hammer should be selected if the general run of work is of the size given.

Diameter of stock	Size of hammer
$3\frac{1}{2}$ in.	250 lb. to 400 lb.
4 in.	400 lb. to 600 lb.
$4\frac{1}{2}$ in.	600 lb. to 800 lb.
5 in.	800 lb. to 1,100 lb.
6 in.	1,100 lb. to 1,500 lb.

When obtaining quotations give:

(1) Nominal size as described above and character of work to be performed.
(2) Style required:
Single or Double Frame?
Cast iron or cast steel frame?
Whether for locomotive frame work (hammer of extra long stroke and clearance)?

Hoisting Engine and Boiler for General Hoisting Work

Note.—For outline of ordering-requirements for haulage-engines for inclines, etc., see p. 170.

(1) **Service.**—State whether for quarry, pile-driving, general building, bridge-building, logging, or other use.
(2) **Capacity.**—Give either (1), the size of cylinders desired, or (2) state the average and maximum loads to be handled and the speed for same.
(3) **Style.**—State whether single or double cylinder; reversing or non-reversing; one, two, three or four drums; with or without slewing drums; whether belt pulley is required; whether to be mounted on dock wheels.
Also state any special requirements.
(4) **Number of Units Required?**
(5) **Fittings.**—Enumerate such of the following fittings as are to be supplied, and also state which are *not* to be supplied. Oil cups, wrenches, sight-feed lubricator, drain-cocks, throttle valve, boiler fixtures ready for steam, anchor-bolts.
(6) **Spares.**—State whether any spare parts are to be supplied; (enumerate, or call for recommended list).
(7) **Shipping.**—State whether there are any limitations on weights of pieces as affected by shipping facilities.

Rock Crusher, Etc.

Rock crushers are of two general types, "jaw" and "rotary." The former are usually preferred when the crushing plant is to be portable, while the latter are better adapted to large, stationary installations.

(1) State style of crusher preferred, and purpose of plant.
(2) Kind of rock to be reduced? Whether wet or dry?
(3) To what fineness is it to be crushed?
(4) State capacity in tons per hour.
(5) Is machine to be stationary, portable or semi-portable.
(6) State any experience with previous machines, or any preferences you may have, that will influence your choice of this outfit.
(7) State whether any of the following complementary equipment is to be furnished.
Steam engine and boiler, gasoline engine or motor to drive (if the latter, state the kind of current to be used and its voltage, and if alternating, state also its phase and frequency).
Driving belt.
Stone elevator; state height.
Revolving Screen.
Storage Bin (portable).
Bin Gates.
Spare Parts.

SEC. II. MACHINE AND PLANT DETAILS

Metallic Piston or Valve Rod Packings

The following information schedule is taken from that issued by the U. S. Metallic Packing Co.

(1) Number of Packings Wanted:
For Valve Rods; For Piston Rod? (Write a separate specification for each.)
(2) Diameter of Rod?
(3) Diameter of Face of Stuffing Box?
(4) Diameter of Stuffing Box, inside?
(5) Diameter of Opening into Cylinder or Chest?

(6) Depth of Stuffing Box?
(7) Number of Stud Bolts?
(8) Distance between Centres of Stud Bolts? (Send sketch.)
(9) Position of Stud Bolts?
(10) Length of Stud Bolts?
(11) Diameter of Stud Bolts?
(12) Travel of Valve Stem, Cut-off, or other rod of varying stroke?
(13) Distance between Cross-head and Stuffing Box? (Send sketch.)
(14) Position of Guides?
(15) Is engine vertical or horizontal?
(16) If Vertical, is rod out of Top or Bottom of Cylinder?
(17) Is Engine High or Low Pressure?
(18) Give Maximum Steam Pressure.
(19) If for Steamer, Ferry or Tug, give name.
(20) Is Superheated Steam used?

Hydraulic Packings (Leather)

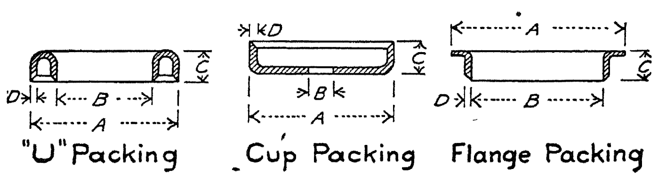


Fig. 44.—Hydraulic packings.

(1) Send sketch as above.
(2) Service for which intended?
(3) Kind of liquid to be used, water, oil, glycerine, chemicals, etc.?
(4) Special requirements, if any, such as kind of leather, treatment, etc.?
(5) Number of packings required?

Injectors

(1) State for what **Service** injector is to be used, stationary, portable or traction engine, locomotive, or marine.
(2) State **Number** and **Kind** of **Boilers** to be fed; and give Horse-power, or, if this is not known, give the following particulars:
For Flue Boilers.—Diameter and length of shell; and number, diameter and length of flues.
For Multitubular Boilers.—Diameter and length of shell; and number, diameter and length of tubes.
For Vertical Boilers.—Number, diameter and length of tubes; diameter and height of fire-box; and size of fire-door opening.
For Loco. Type Boilers.—Number, diameter and length of tubes; width, length and height of fire-box; and size of fire-door opening.
For Marine (Scotch) Type Boilers give data asked for under Flue and Multitubular boilers above.
(3) State **Steam Pressure**—highest, lowest and average.
(4) Is the injector to be of the **"Lifting"** type (raising its suction water), or of the **"Non-Lifting"** type (working under a head of water)? In the former case give the vertical suction lift; in the latter the water pressure.

(5) Give **Distance of Water supply** horizontally from injector, and size and description of suction line.
(6) What is the average and maximum **Temperature** of the feed water?
(7) **How many** injectors are required? Is each one to be of sufficient size to supply the whole battery, or otherwise?
(8) Are **Connections** to be supplied screwed, flanged or blank (for brazed copper connection)?
(9) State whether any of the following **Fittings** are also to be furnished.
Steam valve, suction valve, strainer, check valve, discharge valve, overflow funnel, water pressure balanced valve (for suction line subject to irregular high pressure), dirt stop (strainer fitting for suction line).

Ejectors

Ejectors (or Exhausters) are most commonly used for elevating water or other liquids, and for exhausting or priming pumps, etc. Their use has in recent years, however, been extended to cover almost any of the operations of ordinary pumps, air compressors, vacuum pumps, and heaters. The information necessary to submit to the makers, for obtaining quotations for the more usual operations, is outlined below. The more complicated or unusual cases should be handled by an engineer, who should submit all pertinent information to the manufacturing specialists.

(1) Describe the **use** to which the ejector will be put.
(2) Describe the **nature of the liquid**; its specific gravity or weight per cubic foot (if other than water); and its temperature.
(3) What will be the minimum and average **steam pressures** at the ejector? If there is doubt about the sufficiency of steam available, state conditions and ask for builder's opinion.
(4) (For Lifting Liquids.) Will the ejector be of the "**Forcing**" type (placed within about 5 ft. of the water level); or of the "**Lifting**" type (placed as high as the steam pressure and the temperature of the liquid will allow)? In either case, state how high (vertically) above the water level the ejector will be placed, and the total height (vertically) to which the liquid has to be raised.
(5) (For Lifting Liquids). If the **suction** consists of piping, describe same, giving size of pipe, number of bends, etc. Also, describe discharge line in the same manner.
(6) (For Priming Pumps). Give all the information called for above, and state **size of pump** and the approximate time in which it is desired to prime it.
(7) (For Lifting Liquids). **How many gallons** per hour are to be raised?
(8) How many **units** are required? Is each one to be of sufficient size for the above work, or otherwise?
(9) Is a **strainer** required?

Special Uses

Information to be given in addition to the above.
(10) **For Driven Well Service.** State flow of well (capacity of ejector *must not* be greater than this). State size of casing (I. D.); depth of casing; depth to water level when not running; depth to water level when being pumped.
(11) **For Sand or Mud Eduction.** Send sketch of the situation. Will steam or water be used for lifting?

(12) **For Lifting Corrosive Liquids.** For this purpose, ejectors of lead, stoneware, C I, etc., may be used as best suited. Describe the character and strength of the liquid. State whether steam or air is to be used for lifting?

(13) **Water-jet Eductors.** These are used for draining sumps, etc., with the aid of water from ordinary or special pressure mains. Send a sketch of the conditions and give the water pressure available. A check valve may be installed in the suction. The eductor may be made automatic in action by means of a float device.

Chain Drive Material

(For ordering sprockets and chain for a power transmission.)

(1) Submit sketch showing: relative position of shafts, driving and driven sprockets designated, direction of rotation, distance between centres of shafts.
(2) What is the horse-power to be transmitted?
(3) Service which drive is to perform?
(4) Is load steady, pulsating, or irregular? Is drive started or stopped suddenly?
(5) Will drive run under dirty conditions? Describe same.
(6) Diameter and speed of driving shaft?
(7) Diameter and speed of driven shaft?
(8) Can distance between shafts be adjusted? How much?
(9) If drive is to replace leather or rubber belts, give diameter of pulleys, and width and thickness of belt; also, if drive is other than straight, describe by sketch.
(10) State which of the following items are to be supplied, and which are *not* to be supplied; driving sprocket with key and set-screw, driven sprocket with key and set-screw, chain, take-up, idler pulley or sprocket with shaft and bearings, oil-guard complete with supports (see sketch), spare links and pins, repair links, repair block.

Sprocket Wheels

(1) Give number of chain sprocket is to work with.
(2) Give number of teeth, or give approximate (pitch) diameter required.
(3) State whether it is a *driven* or *driving* sprocket.
(4) Give exact size of bore, and state whether it is to be key-seated or set-screwed. Note.—When size of key-seat is not given, maker's standard is supplied.
(5) When wheels have clutch hubs, or hubs on one side only, state whether it is to be on the right or left-hand side as top of wheels turn from you.
(6) If a number of sprockets are required, submit the above information in a table made out as follows:

No. reqd.	No. of chain	Pitch diam.	No. of teeth	Driver or driven	Bore	K. S. or S. S.	Remarks

Spiral Conveyor Material

For an outline for an engineer's design of a spiral-conveyor installation, see p. 72.

(1) Is a solid scroll, ribbon, cut-flight, double flight, mixer-paddle, or other type of spiral required?

(2) Give diameter of scroll.
(3) Is scroll to be right-hand, or left, or both?
If in doubt, send sketch showing direction of travel of material and required direction of rotation.
(4) Give length of conveyor required, over-all of inlet and discharge spouts, or inside-to-inside of end-heads.
(5) Of what material is scroll to be made, steel plate, extra heavy steel plate, or cast iron?
(6) Of what material is trough to be made, steel plate, wood with curved steel lining, or special?
(7) Are scroll or trough to be galvanized?
(8) Is trough to be of standard size, or extra large? If the latter, describe requirements.
(9) Will the driving belt operate the conveyor direct, or through a spur gear reduction, or will a bevel-gear arrangement be used?
(10) Give size and speed of driving shaft.
(11) At about what speed is scroll to operate?
(12) State which of the following items are to be furnished and which are *not* to be furnished:
Scrolls (including hangers and couplings), trough or trough lining, end bearings, end driving gearing complete, pulley, driving chain or belt, driving sprocket or pulley (for line-shaft).

Belt, Slat or Scraper Conveyors

For an outline for an engineer's design, see p. 71.

(1) Length of Conveyor, c. to c. of end pulleys?
(2) Is conveyor to be level or inclined, or partly level and partly inclined?
Send a sketch showing the slope, length, etc.
(3) State the material to be handled. Give weight per cubic foot, and average, largest and smallest sizes of pieces.
(4) Is the material wet or dry, hot or cold? Give temperature. Does it possess destructive properties, chemical or physical?
(5) Give average quantity of material to be moved per hour in pounds, bushels or cubic yards.
(6) Give maximum capacity per hour and explain the governing conditions.
(7) In what manner is material to be fed to the conveyor; by hand or by dredges, bins, chutes, crushers, rolls, etc.?
(8) To what will the conveyor deliver? and how? If at intermediate points, give number of delivery points and state whether they are to be fixed or movable.
(9) From which end will the conveyor be driven? If advisable, would it be possible to drive from other end?
(10) Is the conveyor to be operated from engine, motor or line-shaft?
(11) If to be operated by an existing engine, give size of cylinder, speed, steam pressure and size of pulley.
(12) If to be operated by an existing motor, give horsepower, and size and speed of pulley.
(13) If to be operated from line-shaft, give speed and diameter of shaft.
(14) Of what material is the supporting framework of the conveyor to be made, steel or wood?
(15) Specify which of the following items are to be supplied by the contractor, and

which are *not* to be supplied: All special material entering into the construction of the conveyor proper; the supporting framework complete or the irons only for the supporting framework; the transmission material for the driving end of the conveyor; driving belts; the driving engine; motor pulley; house over the whole.

Bucket Elevators, Etc.

(1) State nature of material to be handled.
(2) Quantity in pounds or bushels or cubic feet per hour.
(3) Height material is to be elevated, and whether perpendicular or at what incline.
(4) Speed and diameter of shaft from which power to drive elevator is taken.
(5) State whether elevator can be driven more conveniently from top or bottom.
(6) If chain belting is to replace rubber or cotton belts, give inside measurements of old leg, width of belt to be replaced, and diameter of head and foot pulleys.
(7) Is the elevator to be of all-metal construction, or is the leg to be of wood?
(8) Which of the following items are to be supplied and which are *not* to be supplied? Main chain, chains or belt; buckets; boot with take-up, shaft and sprocket, etc.; head with shaft and sprocket (or pulley); leg complete (of wood or steel, or irons only for wood); driving gear complete; driving belt or chain; belt or sprocket for line-shaft.

Leather Belting

For an outline of a specification which may be used when purchasing leather belting, see p. 128. The following notes give supplementary information concerning this material and also outline the data to be submitted in case it is not desired to write a formal specification.

(1) Style.
Leather belting is prepared in various forms, the principal of which are oak-tanned, chrome-tanned, waterproofed (dipped in a waterproofing compound after making up), waterproof (made up with waterproof cement, etc.). Prices differ very widely, not only with the grade of leather used but also with the method of composition.

(2) Thickness.
Thicknesses are usually designated as "single," "double" and "triple." A more extended division is also in use and should preferably be adopted in ordering, such as "ordinary single" or "light single," "heavy single," "ordinary double" or "light double," "heavy double," "light triple" and "heavy triple;" the grades merge into one another, but permit of a more definite description of the weight of belt needed. In case large, triple belts are required, however, it is best to calculate the thickness required and so specify.

(3) Order List. State:
(a) Number of lineal feet.
(b) Width.
(c) Thickness.
(d) Style.
(e) Cement for making (———) joints in (———) in. belt (give list).
(f) ——— doz. of belt laces required.
(g) Whether any of the belts are to be endless (send sketch of drive).
(h) Whether material is to be packed for export.

Canvas Belting

Under this term is included all that class of belts having woven-cotton or canvas as a base.

For a specification-form which may be followed in case it is desired to present same, see p. 128.

(1) Style.
State whether woven canvas, stitched canvas, rubber-canvas, treated cotton fabric, "Balata," etc., is required.

(2) Thickness.
The thickness of canvas belts is usually given as "4-ply," "5-ply," etc., according to the number of layers of canvas used, but the thickness and quality of the latter are variable quantities, so that the term is not a sufficient unit for comparisons.
The weight required may be specified in three ways: (1) by giving the thickness of the equivalent leather belt, (2) by stating the ply (when the make to be used is decided upon), and (3) by stating the belt-speed and horse-power to be transmitted. The first method is quite generally used and is probably good enough for most purposes if the bidders are required to state the ply of the belts proposed; follow the six-division classification for leather belts given on p. 185, (2).

(3) Order List. State:
(a) Number of lineal feet.
(b) Width.
(c) Equivalent leather belt thickness (see above).
(d) Style.
(e) Material for making (———) joints in (———) in. belt (give list).
(f) Whether any of the belts are to be endless (send sketch of drive).
(g) Whether material is to be packed for export.

Hack Saw Blades

Quite usually hack saw blades are ordered with no indication being given as to the class of work they are intended for. Blades vary not only in the number of teeth per inch, but in the temper given them; and for cutting different materials, such as soft steel, cast iron, brass, tubing, etc., a different type of saw should be used. To avoid possible dissatisfaction on this account, the information outlined below should be given the dealer or manufacturer.

(1) Number of blades required.
(2) For hand or machine use.
(3) Length.
(4) Number of teeth per inch (if definitely known).
(5) Material to be cut.
In absence of specifications as to cut of tooth, always ascertain, if possible, what class of material is to be cut with the blades ordered, and furnish a
"Regular" tooth for solids in soft steel, a
"Medium" tooth for hard tool steel, cast iron and general work, or where the

same blade will necessarily be used on different classes of work, a "Fine" tooth for brass, black pipe, drill rod, etc., and a "Tubing" tooth for thin tubing, thin sheet steel or brass.

Trolley Track Systems

The following reminders are taken from the catalog of the Coburn Trolley Track Mfg. Company.

(1) If possible send a scale sketch of proposed lay-out showing us exactly what you wish to accomplish and your idea of doing it.
(2) If you have no idea how best to lay out a system, send a ground plan with the points to be connected by the system accurately located thereon and such other data as will enable us to clearly understand your requirements so that we can lay out same, and we will then submit you a plan for approval.
(3) State maximum load to be moved and whether for constant or for occasional use.
(4) Advise if possible the application of the track best suited to your conditions as shown by the systems illustrated in this catalog, especially as regards the kind of track-bracket wanted.
(5) Give some idea of size of loads aside from weight.
(6) When there is to be curved track we desire to know the largest radius possible to use; the larger the curve the better the results obtained.
(7) State the distance from floor to under side of roof trusses or floor timbers to which support for the track is to be attached or suspended; also give distance apart on centers, size of timbers or iron trusses, how constructed and location of same on plan.
(8) State the amount of head-room between top of load and proposed location of track bed, and the type of hoist to be used.
Note.—It is better, when possible, to have track within 8 or 10 ft. of floor, providing of course it will not in any way interfere with the proper handling of your goods.

Car Wheels and Axles

Information to be submitted for quotation or order.

(1) Gauge of Track.
(2) Diameter of Wheels.

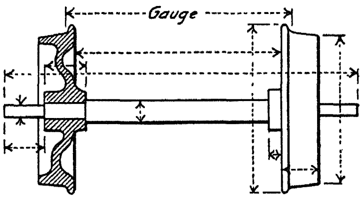


Fig. 45.—For outside bearings.

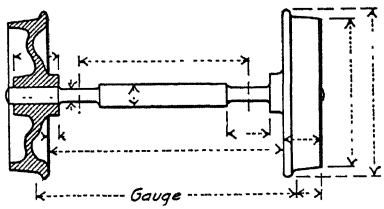


Fig. 46.—For inside bearings.

(3) Diameter of Axles.
(4) Outside or Inside Journals? Give dimensions.
(5) Load per axle.
(6) Width of tread and height of flange.

(7) Fill out the dimensions in a sketch like Fig. 45 or 46.
(8) State material preferred for axles; hammered iron, carbon steel, etc.
(9) State material preferred for wheels; cast iron with chilled treads, cast steel (with or without chilled treads).
(10) How many pairs required?

Car Wheels

Information to be submitted for quotation or order.

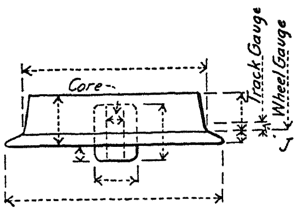


Fig. 47.—Car wheel for industrial track.

(1) Supply sketch with dimensions as given in Fig. 47.
Note No. 1.—The distance J is about 1/4 in. for Industrial Tracks.
Note No. 2.—The diameter of hole to receive axle is the diameter of the cored hole, and will be less than the diameter of the axle by the amount required for boring.
(2) Are the wheels to be made of cast-iron with chilled treads, or of cast-steel (with or without chilled treads)?
(3) How many wheels are required?

Portable Track

(1) Gauge of track (distance inside of rail heads).
(2) Weight of rail per yard; or, send sketch of section or small piece of old rail; or, give information as to maximum wheel load, wheel base producing this load and road-bed conditions, so that required weight of rail may be calculated.
(3) Length of (straight) track required.
(4) State preferred length of sections and number of ties per section if known.
(5) State any preference as to type of (steel) tie and method of attaching rail.
(6) State preference as to style of rail connections; whether splice shoes, or fish-plate joints; in latter case give drilling if required to match existing rail (distance from end of rail to centre of first hole and distance from centre of first hole to centre of second hole, and diameter of holes)
(7) Curves.—Besides information in (1) to (6), state radius (to centre line of track), or give distance (for outer rail) subtended by a chord of, say, 10 ft. so radius may be calculated; state total number of degrees of curve desired, or number of sections (giving length).
(8) Switches.—Besides information in (1) to (6), state whether right, left, two way or three way; radius desired; with or without ground-throw (lever); state whether ordinary or climbing switch is desired.
(9) Crossings.—Besides information in (1) to (6), state angle of crossing; curvature (if any); and if gauge, etc., of tracks is different, give complete information for both; if crossing is complicated submit the information by a sketch.

Railroad Frogs, Switches, Crossings, Etc.

Fig. 48 illustrates the difference between right- and left-hand turnouts, and also exemplifies the terms in use for this material.

I. Rail Section

Send either (1) the mill and section number, or (2) an exact outline drawing of the rail.

On new rails the section number is usually given; old rails do not always show this. Do not mistake the marks giving the year and month of rolling (shown by figures and straight lines respectively) for the section number. On rails of foreign manufacture it will be necessary to send a sketch of the section.

A sketch of the section may be obtained, (1) by tracing the end on a sheet of

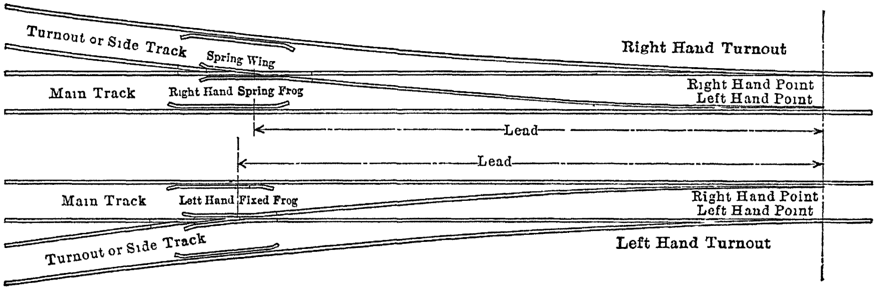


FIG. 48.—Diagram of turnouts.

paper, (2) by making a hammered impression of the end on a piece of paste-board, (3) by forming two pieces of lead wire to the rail and sketching from the template thus obtained, (4) by some rail-section drawing device.

II. Frogs

(1) Give section of rail as described above.

(2) Give (a) "number" of frog and (b) length of frog over-all, or length of main point rail, or both.

Note (a).—The "number" of the frog is the ratio of its length to its

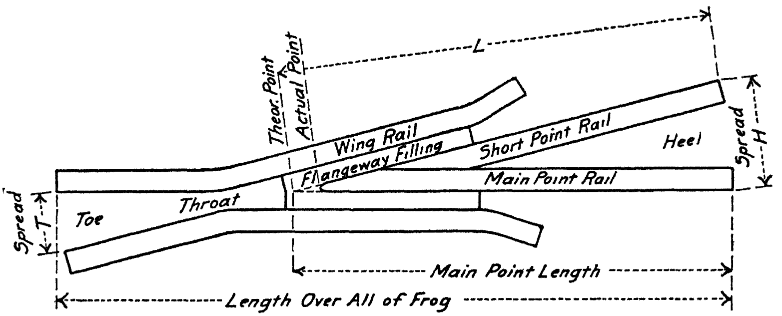


FIG. 49.—Railroad frog.

spread. Thus, in Fig. 49, if the distance "L" is 60 in. and the corresponding spread "H" is 15 in., then 60 ÷ 15 = 4, and this is the number of the frog. As a check on this figure, add together the spreads at heel and toe ("H" + "T") and divide into the length over-all. Thus, if "T" = 7 in. and the length over-all = 88 in., then 88 ÷ (15 + 7) = 4

Note (b).—The "length of frog" (length over-all) varies from about 4 ft. for No. 4 frogs of light rail sections, to 15 ft. for frogs of up to No. 12 size made of heavier sections. If unable to determine this (and the length

of the main point rail), ask for the maker's standard length for the turnout in question.

(3) Style of Frog.
State whether a Stiff, Spring-rail or Double-pointed (Crossing) Frog is required.
Also state construction preferred; whether bolted, clamped, manganese steel inserted, solid cast frog (for light rails), steel plate riveted (for light rails), etc.
In case of Spring Frogs state whether they are for right- or left-hand turnouts (see Fig. 48).

(4) Details.
Send sketch showing spacing and size of splice-bar holes. If bonding hole is required, include in sketch.

(5) Material Supplied.
The regular equipment consists of the assembled frog ready to be spiked and bolted in place. Guard rails, fish plates, splice-bolts, rail braces and foot guards are extras

(6) State number of items required.

III. Switches

(1) Give section of rail as described above.

(2) Style of Switch.
State whether a standard split switch, three-throw split switch, derailing switch, T-rail tongue switch and mate, or stub switch (see V. below) is required.
Is head-rod to be plain or adjustable? with or without spring? how many rods preferred? Are switch rails to be plain or reinforced?
Is spring (for automatic closing) required?
If three-rail split switches are required, a sketch of turnout must be submitted.

(3) Main Dimensions.
Gauge of Road.
Length of switch rails.
Note.—Fifteen feet is the standard length for standard railroad work, this being reduced for lighter rails or sharper turnouts.

(4) Details.
Send sketch showing spacing and size of splice bar holes.
State throw of Stand which will be used with switch.
State diameter of hole in end of head-rod to which the connecting rod of your stand will attach.

(5) Material Supplied.
(Regular Equipment): Switch rails (two), head-rod (with details as specified), tie-bars (one, two or three), switch lugs, friction plates (with or without rail braces).
(Extra Equipment): Stop lugs, switch stand with connecting-rod.
State which of the above items are to be supplied and which are *not* to be supplied.

(6) State number of complete switches required.

IV. Switch Stands

(1) State throw required.

(2) Style of Stand.
State whether vertical lever switch stand, parallel throw stand (for light switches), plain ground throw with weighted lever, "plantation

stand," ground throw for three-throw stub switches, automatic ground throw, ditto with high target, pony switch stand, high switch stand (automatic or non-automatic).

(3) Details.
Send sketch of "lamp fit" required (to suit lamp sockets).
Send sketch of end of head-rod of switch, so that connecting-rod may be furnished to suit.

(4) Material Supplied.
State which of the following items are to be supplied and which *not.*
Stand, connecting rod, lamp.

(5) State number of stands required.

V. Stub Switch Fixtures

The material for one switch consists of two head chairs and two or three tie bars.

(1) Give section of rail as described above (I).
(2) Gauge of track.
(3) Are head chairs to be for a single or three-throw turnout?
(4) What is the throw of switch stand?
(5) Is a switch stand to be included?
(6) If so, what style, etc. (see IV)?
(7) Number of items required.

VI. Crossings

(1) Angle of Crossing. Give angle between intersection of tracks. If gauges are different, or if either track is curved, send a plan so that relative locations may be made clear. Note that the angle of crossing on curves is between the tangents to the curves at the point of intersection of centre lines.
(2) Gauge of Tracks. Give gauge of tracks, and, if different, send a plan showing relative location of the tracks.
(3) Size of Rails. Give size of each rail as described in I. Note that if the sizes of the rails are different, it is customary to make the crossing of the heavier size of rail, and to use offset fish-plates, etc., for connecting to the lighter rail.
(4) Style and Service. State style of traffic on each track (whether steam or street road, etc.), and otherwise indicate grade of construction desired.
(5) Details. Send sketches showing spacing and size of splice-bar holes for each track. If bonding holes are required, include in sketch.
(6) Material Supplied. Fish-plates are not regularly supplied; these together with step chairs (for offset connections), must be specifically ordered.
(7) State number of crossings required.

VII. Guard Rails

(1) Give section of rail (see I) of which guard is to be made.
(2) Give flange clearance required, *i.e.*, width of flangeway between track rail and guard rail.
(3) Give length of guard rail.
(4) Style and Finish. State how much work is to be done on the rail, using the following schedule:
Des. No. 1.—Rail bent only.
Des. No. 2.—Rail bent and flange cut for flange clearance specified.
Des. No. 3.—Rail bent, flange cut for clearance as above, and notched for spikes.

Des. No. 4.—Rail bent, flange cut for clearance as above, and furnished with bolts.

Des. No. 5.—Rail bent, flange cut for clearance as above, and furnished with clamps.

(5) Details. If special bend is required, send a sketch.
(6) State number of items required.

VIII. Derailing Devices for Electric Roads.

This refers to the derailing switch in electric road tracks placed in front of a steam road crossing, which requires for its operation that the conductor cross the steam road tracks to close the switch to allow the car to pass. The material required consists of the switch, the ground throw or other operating device, and the connecting-rods or wire rope.

(1) State whether an ordinary split switch is required, or a tongue switch for use in paved streets.
(2) Give section of rail (see I) of which switch is to be made.
(3) Are cars to be derailed to the right or left hand?
(4) What type of operating device is required: a ground throw with gas-pipe throw rods, or a handle-box with galvanized-wire rope in pipe conduit?
(5) State any preference as to design (to suit depth of paving, etc.)
(6) Give distance between switch and ground throw or handle-box (75 ft. is usual).
(7) Send sketch showing spacing and size of splice-bar holes; also bond holes, if required.
(8) Material Supplied. State which of the following items are to be supplied and which are *not* to be supplied:
    (a) For Split Switch and Ground Throw Installation: Switch rail, head-rod with spring, switch lugs and friction plates with braces; ground throw; throw rods, turn-buckle, bell-cranks and connecting-rod.
    (b) For Tongue Switch and Handle Box Installations: Tongue switch complete with spring and guard steel; handle-box complete; galvanized-wire rope throw with pipe conduit, and crank box (at switch) complete.
(9) Number of items required. (Note that two sets are required for a single-track crossing.)

IX. Street Railroad Work

(1) Send a plan of the curves, turnouts, etc., required.
(2) Give section of train rail as per I; also of guard rail.
(3) Send sketch showing size and position of splice and bond holes.
(4) Gauge of track?
(5) Show on the drawing radius of curves, distance between track centres, width of each street between curbs, angle of intersection of streets, direction of traffic, etc.
(6) State any special requirements.
(7) Number of items required?

Derricks and Derrick Irons

(1) Kind of Derrick required: Guy; Self-slewing Guy; Stiff Leg; Full Circle Stiff Leg; Traveling Stiff Leg; Crane Derrick; Tower Derrick; Jinniwink; or special.
(2) Is derrick to be constructed of steel or wood? Or is boom to be of steel and mast, etc., of wood?

(3) Are members to be in short lengths, *i.e.*, is a sectional derrick required?
(4) Heaviest load to be lifted?
(5) Length of boom? Length of Mast? Size of Boom? Size of Mast?
(6) For a guy derrick, state number of guys desired, and their lengths.
(7) Power. State whether hand, horse, steam, or electric power is to be used, and any special requirements of either. In case of electric power, state the voltage, and whether direct or alternating current; and, if the latter, give also the phase and frequency.
(8) Will derrick be slewed by hand or power?
(9) Material to be supplied.—State which of the following items are to be supplied: Boom, mast, stiff-leg, sill and brace timbers; ditto of steel; trussing rods and details; irons for mast and boom bottom, plain mast bottom, step and base plate, bull-ring, mast top, boom point, guy cap, mast bracket, stiff-leg irons, stiff-leg brace iron, guide sheaves; standing gear consisting of guy-wires with end shackles and other fastenings; running gear consisting of hoisting rope, boom line, slewing line, and blocks; hand power crab; horse-power, hoisting engine (see p. 179); electric hoist.
(10) State clearly what material is *not* to be furnished.
(11) For what service is derrick to be used?
(12) State any unusual conditions, and, if not otherwise taken care of, give information concerning the following: height to which load is to be raised; amount to be slewed; speed of hoist; pull on single line; type of irons desired for foot of mast and boom, boom point, mast top, etc.; details of hand power desired; details of hoisting engine (see p. 179); quality of hoisting rope.
(13) Number of units required?

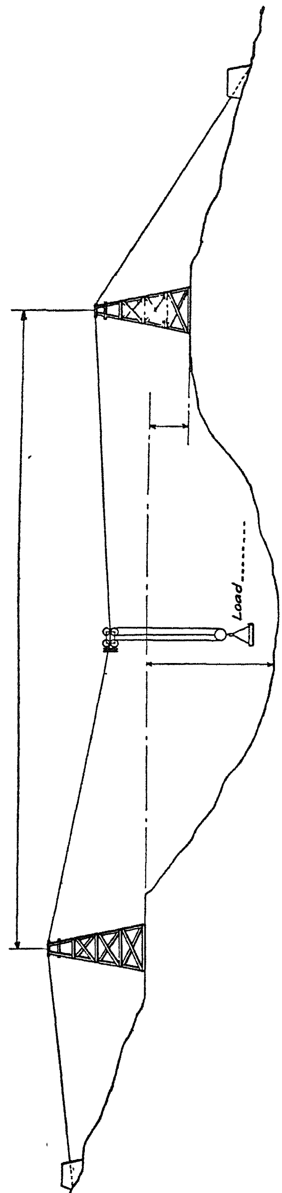


FIG. 50.—Typical diagram for cableway dimensions.

Material for Cableway

The following reminders apply more particularly to cableways intended for excavating, their most usual function; they may be used, however (with evident modifications), for cases where the cableway is to be installed for the purpose of placing steel for a bridge, depositing masonry, etc.

(1) General purpose of the cableway?
(2) Span, centre-to-centre, of towers?
Note.—Usual maximum span is from 1,800 to 2,000 ft., which, however, may be exceeded under favorable conditions.

(3) Kind of material to be handled? Describe completely enough so that buckets, etc., may be designed to handle same in a satisfactory manner.
(4) Average load in pounds?
Note.—The average load for loose rock is from 6,000 to 12,000 lb.
(5) Maximum load in pounds that will have to be carried? Frequency with which such loads will occur?
(6) Capacity to be handled per hour in pounds?
Note.—If figures are given in tons, be sure to state whether "short" tons of 2,000 lb. or "long" tons of 2,240 lb. are meant.
(7) Total amount of material to be handled by the installation?
(8) Amount to be handled per year?
(9) Is the ground where cableway is to be located level, rising or hollow?
(10) If not on a level, how much higher will base of one tower be than base of the other?
(11) Submit a sketch similar to Fig. 50, filling in the dimensions indicated. This sketch should preferably be to scale, but not necessarily so. Carry profile lines back as far as necessary from towers, so that location of anchorages may be determined.
(12) State whether there are any buildings or elevations over which cable is to pass, indicating position and height on the profile sketch.
(13) From what points is the material to be taken?
(14) To what points is it to be delivered?
(15) Are both towers to be stationary, both traveling, or one stationary and the other traveling?
(16) Will steam, electricity or compressed air be used for operating the cableway? If steam or air, give pressure per square inch *at the hoist*. If direct current, give voltage; if alternating current, give voltage, phase and frequency.
(17) At which end may hoist be most conveniently placed?
Note.—Hoist should, as a rule, be placed at highest point.
(18) State what material is to be furnished and what is *not* to be furnished, as follows:
Special material of the cableway proper, including main cable, fall rope, trolley rope, cable carriage, fall block, trolleys, bucket; material for tower tops complete; irons for towers; wood for towers (not usually supplied); irons for anchorages; hoisting engine, and boiler.

SEC. III. MATERIALS OF CONSTRUCTION

Ordering Structural Material

Methods and details of ordering structural material differ somewhat in various shops, not only among different companies but also in different shops of the same company. The differences occur both in the forms used and in details affected by shop methods. The directions given below refer to average conditions. With regard to the forms used in ordering, it may be remarked that in the smaller shops the order list is made out and completed by one man who makes the necessary allowances for clearance, milling, multipling, etc.; while with the larger bridge companies it is the custom to have the ordering engineer make out a detail list, leaving to another man (more familiar with

stock, shop customs, etc.) the summarizing of the items, ready for handing to the mill.

General

Place orders promptly for main material and details which will take longest to get out, or which are required at building site in advance of main shipment. A variation of 3/8 in. either way is allowed the mill, and all ordering must take care of this possibility.

In ordering material for many similar pieces, roof-trusses for example, it conduces to accuracy to bill, say, one-half of the truss and call for total number of half-trusses required. For this purpose the "Advance Bill" should have two rulings, one for the detail list and the other for the summary or "Ordered" number and length.

Beams and Channels

Bill beams in foundation neat.

Bill beams framing to beams, 1 1/2 in. short (to nearest 1/2 in.) of distance c. to c.

Bill beams framing to columns, 1 in. short (to nearest 1/2 in.) of metal-to-metal distance.

Bill beams framing to riveted girders, same as for col's.

Bill beams with mitred ends, 1 in. long to allow for shop cut.

Bill beams for crane runways, resting on bracket, 1 in. short (to nearest 1/2 in.) of c. to c. distance.

Bill purlins 1 in. short (to nearest 1/2 in.) of c. to c. distance.

If end-connections are to be milled after riveting on, increase thickness of connection angles.

Column Material

Bill main column material 1/2 in. long for milling one end, 3/4 to 7/8 in. long for milling both ends. Bill to nearest 1/4 in. Deduct for cap plate.

Bill column details (shelf-angles, stiffener-angles, etc.) in 30-ft. lengths, stating approximate lengths to which same are to be cut. If ends are to be milled after riveting on of cap angles, increase thickness of same.

Bill lattice bars in 20-ft. lengths. Order thick "slabs" (for column bases) by number and finished dimensions (*i.e.*, as sketch plates) and call attention to same so that mill may make proper allowance for cutting.

Plate Girder Material

Distance b. to b. of flange-angles should be 1/2 in. more than the width of web plate which should be of even inch width.

Bill web plates of girders not milled at ends or at splices, 3/4 in. short of over-all distances. If milled at end or splice, allow 1/2 in. for one, 3/4 in. for two millings.

Bill flange angles 3/4 in. long. For curved end-angles, add 6 in.

Bill full-length cover-plates 3/4 in. long; less than full length, neat length: mark "U.M." (Universal Mill, *i.e.*, rolled edges).

Bill stiffener angles with fillers under, 1/4 in. long; crimped stiffeners, add depth of each crimp plus 1/2 in. for each crimp; for fitted stiffeners over 5/8 in. thick, add 1/2 in. for one, 3/4 in. for two millings; end stiffeners to be milled, increase thickness.

Bill fillers under stiffener angles exact length, *i.e.*, 1/4 in. clear each end, making allowance for over-run of angles.

Bill web-splice plates, reinforcing web plates, etc., as for fillers.

Bill lateral angles scaled length plus 1 1/2 in.
Bill lateral plates in lengths of about 20 ft.; detail wing plates so as to "multiple" (Fig. 51).

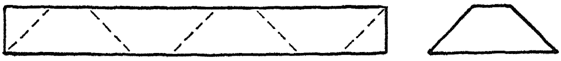


FIG. 51.—Ordering wing plates "Multipled."

Roof-truss Material

Bill chord angles 3/4 in. long.
Bill web members 1 1/2 in. longer than scaled length, and multiple to lengths of about 30 ft.
Bill gusset plates in lengths of about 20 ft.; detail wing plates so as to "multiple" (Fig. 51).

Miscellaneous

For milling ends, in general allow 1/2 in. if milled one end and 3/4 to 7/8 in. if milled both ends.
Plates planed on edge, add 1/4 in. for each edge.
Plates planed on top or bottom, add 1/16 in. for each side planed up to 36 in. × 36 in. in size, over that add 1/8 in. Plates over 7/8 in. thick, add 1/16 in. to above allowances, or for slabs add 1/8 in.
Detail wing plates so that they will "multiple," saving cuts and material; see Fig. 51.
Plates should not be ordered as "sketch plates" unless they are over about 36 in. wide and 5/8 in. thick. The capacity of the shop shears, the extra cost for "sketch plates," the cost of shearing in the shop, and the scrap value should all be considered when there are a large number of plates.
Allowance for finish on pins:

Up to 4 in. diam. allow 1/8 in.
4 1/4 in. to 6 1/2 in. diam. allow 1/4 in.
6 3/4 in. to 10 in. diam. allow 1/2 in.
Above 10 in. diam. allow 3/4 in.

and order of nearest size larger regularly rolled in case the addition does not give an even figure.
Long channels, etc., for bridge web-members, etc., not requiring milled or beveled ends, order neat length, as the 3/8-in. variation does not affect.

STEEL PLATES FOR BOILERS, TANKS, ETC.

This material is usually ordered by gauge, but paid for by weight (the actual shipping weight). Prices are quoted per 100 lb. of material for a stated delivery. The customary allowable overweight on material of various widths and thickness when ordered to gauge, as adopted by the Assn. of Am. Steel Mfrs., is given in various steel handbooks; plates thus ordered are not liable to under-run in weight.

For Dished Heads, see p. 197.

An example of a specification for this class of material is given on the following page.

List of Plates Required For Five 7 ft. 0 in. × 20 ft. 0 in. R. T. Boilers

Firebox Steel Plates

10 — 80 1/2 × 266 × 1/2 for boiler shell.
5 — 80 1/2 × 263 × 1/2 for boiler shell.
5 — 99 1/2 × 81 1/2 × 5/16 for boiler drum.
15 — 16 3/4 × 80 1/2 × 7/16 for boiler butt straps.
15 — 11 × 80 1/2 × 7/16 for boiler butt straps.

The above butt straps are to be cut from plates with the grain running in the same direction as that of the shell plates to which they are to be riveted.

Flange Steel Plates

Ten Circular Plates of the proper diameter and 5/8 in. in thickness to form ten boiler heads 263 7/8 in. in circumference, total depth of flange 5 in. Five of above heads to have a flanged manhole 12 in. × 16 in., as shown on print.

Ten Circular Plates of proper diameter and 3/8 in. in thickness to form ten dished heads 30 in. in diameter. Five of above to have a 4 in. × 6-in. flanged handhole at centre.

Quality of Material

To conform to the specifications of the American Society for Testing Materials, adopted 1901.

Plates and Heads to be Stamped

Each plate shall be distinctly stamped by the manufacturer with the heat number and in at least five places in the following manner: At the four corners, at a distance of about 12 in. from the edges, and at or near the centre of the plate, with the name of the manufacturer, place where manufactured, brand and lowest tensile strength.

Each head shall be distinctly stamped by the manufacturer on each side with the name of the manufacturer, place where manufactured, brand and lowest tensile strength, stamps to be located so as to be plainly visible when the head is finished.

Dished Heads for Boilers and Tanks

The following directions for ordering dished heads, flue holes and manholes are extracted from the catalog of the Glasgow Iron Co. For specifications for material, marking, etc., see above.

Dished Heads

A sketch should accompany all orders for flanged and flanged and dished heads with dimensions filled in, showing:

T—Thickness of metal.
O. D.—Outside diameter of head.
S—Straight flange.
O. R.—Outside radius of knuckle.
Dish—Radius of dish.

Unless otherwise instructed we will flange all heads with the outside radius of knuckle equal to three times the thickness of the metal.

Heads that are flanged and dished should be dished to a radius equal to the outside diameter of the head when flanged.

Manholes

We flange manholes in heads in three styles, Plain Flanged, Reinforced and Banded, all having machine-faced joint seats.

In the **plain flanged** manholes the thickness of the metal is somewhat reduced on the face. This is most pronounced in thin heads.

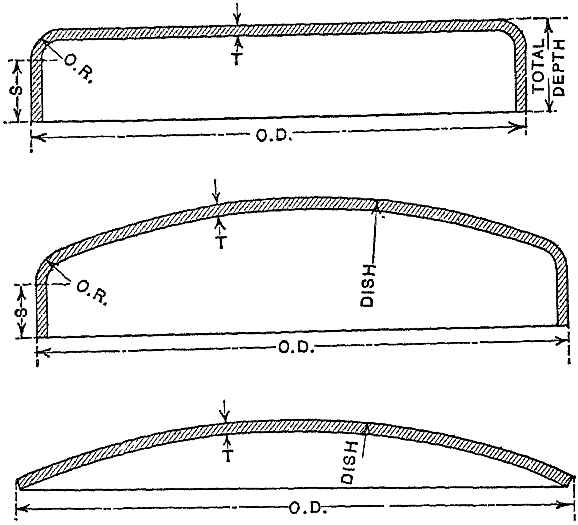
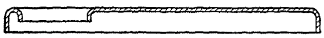
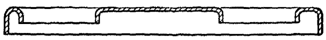


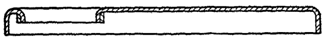
Fig. 52.—Types of dished heads.



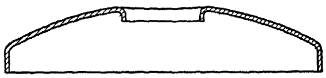
FLAT HEAD WITH PLAIN MANHOLE FLANGED IN



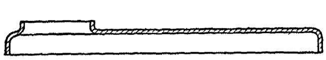
FLAT HEAD WITH TWO MANHOLES FLANGED IN



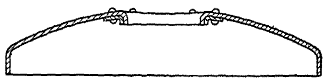
FLAT HEAD WITH BANDED MANHOLE FLANGED IN



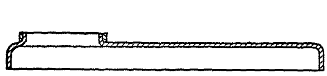
DISHED HEAD WITH PLAIN MANHOLE FLANGED IN



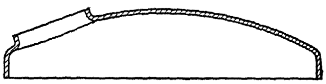
FLAT HEAD WITH PLAIN MANHOLE FLANGED OUT



DISHED HEAD WITH REINFORCED MANHOLE FLANGED IN



FLAT HEAD WITH BANDED MANHOLE FLANGED OUT



DISHED HEAD WITH PLAIN MANHOLE FLANGED OUT

Fig. 53.—Styles of manholes in flanged heads.

The **banded** manhole consists of a band shrunk on the flange and secured with studs. It is applicable to either flat or dished heads, being particularly adapted to the former, where the chief requirement is a broad joint surface.

The **reinforced** manhole is peculiarly adapted to dished heads, where it meets the two requirements of a broad joint surface and the full strength of the head by more than compensating for the metal removed to form the hole. The reinforcing ring is shrunk on and is secured with rivets.

In ordering manholes in flanged heads specify carefully:

1. The size of Manhole wanted.
2. The style, whether Plain Flanged, Banded or Reinforced.
3. The position of the manhole.
4. The direction of the flange, whether in or out.

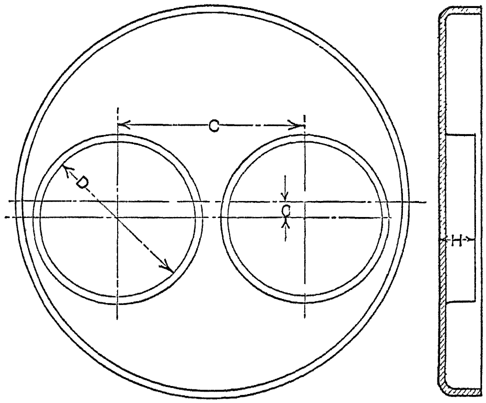


FIG. 54.—Flue holes in boiler head.

Flue Holes

When flue holes are to be formed, a plan of the head in addition to the section should be submitted, which together should show:

D—The inside diameter of holes.

CC—The position of holes.

H—The height of flange and the direction of flange in relation to flange of head.

Flue holes will be flanged with the radius of knuckle equal to the thickness of metal.

Pipe and Fittings

For obtaining bids and placing orders for a miscellaneous collection of pipe and fittings for a special installation in cases where it is not convenient to submit drawings, the form shown in Fig. 55 will be found to possess many advantages.

On small installations the piping may be roughly sketched in on the general plans, or may be laid out as a rough diagram, and the material then taken off and entered on a form as shown.

Its use, however, is by no means confined to small work, for material of varied character to the value of $10,000 has been successfully ordered from one such sheet.

One advantage possessed by the form is that it acts as a "reminder" for material that may be needed.

Another advantage consists in the ease with which the material listed in the shipping bill, or the material as delivered at the plant, may be checked against it. The segregation of the items also aids to quick and close estimating by the manufacturers, as many uncertainties are eliminated.

For "specification reminders" for pipe and fittings, see p. 122.

STANDARD SCREWED FITTINGS

Pipe Size	Ells	Tees	Crosses	Long Sweep Ells	Long Sweep D.Br.Ells	Long Sweep S.B.Tees	Long Sweep Crosses	Globe Valves	Angle Valves	Gate Valves I.S.	Gate Valves O.S.	Gate Valves Indic	Screwed Unions	45° Ells	Plugs	Couplings	Nipples Long	Nipples Short	Nipples Close
6"	12	1												2	2		2	4	
5"	12	1												2	2		2	1	6
4"	6	6	2				18 B F		2	1				4	4		8	12	2
3½"	4									1	18 B F				2	2	2	2	6
3"	9	3	2							1				4	4	4	12	12	6
2½"	48	36	4					4	2	18			12	6	12	6	36	60	6
2"	96	48	6					6	6	18			48	6	12	6	36	72	6
1½"	72	48	6					4	6	12			48	6	12	6	36	108	6
1¼"	60	36	6					6	2	9			36	6	12	6	36	48	6
1"	60	36	6					6	2	12			36	6	12	6	36	48	6
¾"	60	36	6					6	3	18			36	6	12	6	36	72	6
½"	60	24	6					12	3				24	6	12	6	36	48	6
⅜"	24	12	6					36					24	6	12	6	24	24	6
¼"	24	12	6					12					24	6	12	6	24	24	6

STANDARD FLANGED FITTINGS

Pipe Size	Ells	Tees	Crosses	Long Sweep Ells	Long Sweep D.Br.Ells	Globe Valves	Angle Valves	Gate Valves I.S.	Gate Valves O.S.	Gate Valves Indic	45° Ells	Flange unions (Pairs)	Std Flgs	Gaskets "A"	Gaskets "B"
6	2	2											12		
5	2	1											6		
4	1	1											12		
3½													2		
3													4		
2½												36			
2															
1½															
1¼															
1															
¾															
½															
⅜															
¼															

MISCELLANEOUS SCREWED FITTINGS.

Bushings		Bushings		Bushings		Red Tees		Misc		Misc	
2	4×3½	2	2½×1	4	1¼×¾	12	2×2×¾	1	5×4×4 Double Branch Elbow L R	4	2" Cross Valves
2	4×3	2	2½×¾	2	1¼×½			1	6×4×4 " "	1	3" Foster Class "W" Pressure
2	4×2	2	2½×½	2	1¼×⅜			2	2" Swing Check Valves Std		Regulator for use with Vacuum
2	4×1¼	8	2×1½	12	1×¾			2	2 Swing Check Valves E H		Pan Inlet Pressure Varies from
3	3½×2½	2	2×1¼	6	1×½			2	2½" E H Globe Valves		100# to 60# Outlet Pressure
4	3×2½	2	2×1	4	1×⅜			4	2½" Cross Valves		from 15# to 40# for Vertical
4	3×2	6	2×¾	12	¾×½			4	2 "		pipe
4	3×1½	12	1½×1¼	12	¾×⅜			12	¾" Hose Connection Globe Valves		
6	2½×2	12	1½×1	2	¾×¼			2	2" Angle Valves with Universal Joint		
6	2½×1½	6	1½×¾	12	½×⅜				& Extension Stem 4'0" Long		
6	2½×1¼	12	1¼×1	6	½×¼			1	4" Gate I S with Extension Stem 10' 0" Long		

MISCELLANEOUS FLANGED FITTINGS

Red Ells		Red Tees		Red Flanges	
1	8×6			6	6×2
				3	5×4
				2	5×3
				2	5×2½
				2	5×1½

STD W.I PIPE

In Random Lengths of 16 to 20 Feet

Pcs	Size	Length in Ft	Remarks
	6	130	
	5"	75	
	4"	30	
	3½	24	
	3"	80	
	2½	500	
	2"	800	
	1½"	500	
	1¼	300	
	1	500	
	¾"	500	
	½"	250	
	⅜	200	

STD W I PIPE.

Pcs	Size	Length in Ft	Remarks
	¼"	200	

BOLTS — Sq Hd C P Hex Nuts

No	Dia	Length	Remarks
100	¾	3	
100	¾	2¾	
50	⅝	2½	

MISCELLANEOUS MATERIAL

6-4" Pipe Hangers
2-3½ " "
9-3 " "
24-2½ " "
24-2 " "
18-1½ " "
18-1¼ " "
12-1 " "
18-¾ " "

The above hangers to have hinged split Rings and Beam clamps – Max Size of Beam 12" Furnish sufficient Pipe in Random Lengths of 16 to 20 ft for Hangers, providing 4 ft for each hanger

1-2" Std Lever & Weight Safety Valve for 60# pressure Screwed ends.
50-Sq Ft of ⅛" "Rainbow" packing for Steam Joints.

Note :– The Pipe & Fittings listed hereon together with that shown on Cards #2532 & 2535, comprise a complete installation for the Factory under Cont. #188

CONT NO 188 DRWG NO. 2558
JOB 'PHILIPPINE No 4
TITLE LIST OF PIPE AND FITTINGS.

HONOLULU IRON WORKS CO.
29 BROADWAY NEW YORK, U. S. A.

MADE BY ______ TR. BY ERH CHK'D BY ______
SCALE ______ DATE May-12-1913

GENERAL NOTES:—

FIG. 55.—Form for ordering pipe and fittings.

Copper, Brass, Etc.; Sheet, Bar, Wire and Tubing

Sheet

(1) **Material and Temper,** state for:
Copper: whether soft or cold rolled.
Brass. whether "High" or "Low" quality (low brass contains a larger percentage of copper); whether hard or soft temper; or state service for which sheet is intended.
Bronze: Hard or Soft, or state service.
German Silver: Hard or soft, or state service.

(2) **Thickness.**—State in weight per square foot; or by gauge, stating whether Stubs or Brown & Sharpe; or by parts of an inch; or send a small sample.

(3) **Finish.**—Whether Polished one side or both sides. Whether Tinned or Nickel Plated, one side or both sides. Other special requirements.

(4) **Quantity.**—Give number of sheets required, and length and width of each size.

Bar

(5) **Material and Temper,** follow Item No. 1.

(6) **Size.**—Give diameter, size of square, flat, hexagon, half-round, etc.

(7) **Finish.**—Whether Polished, Tinned or Nickel Plated. Other special requirements.

(8) **Quantity.**—Give number of bars and length each if length is to be exact; or, if exact lengths are not required, give total lineal feet desired and state "in stock lengths." Note.—Hard drawn copper bars come in stock lengths of from 10 to 12 ft., brass bars from 8 to 12 ft.

Wire (Bare)

(9) **Material and Temper,** state for:
Copper: Whether Soft or Hard Drawn.
Brass: Whether "High" or "Low" quality ("Low" brass contains a larger percentage of copper); whether Soft, Hard or Spring Wire; or state service for which wire is intended.
Bronze; whether Soft, Hard or Spring Wire; or state service for which wire is intended.
German Silver: whether soft, hard or springy wire, whether Ordinary Resistance (18 per cent.), or High Resistance (30 per cent.); or state service for which wire is intended.

(10) **Size.**—State gauge and whether in Stubs, Brown & Sharpe, or London gauge; or, if no gauge is available, send small sample.

(11) **Finish.**—Whether Tinned, Nickel Plated, Silver Plated, etc. Other special requirements.

(12) **Quantity.**—State length, or number of pounds.

Tubing (Seamless)

(13) Be sure to state "Seamless," otherwise it is open to question whether brazed or seamless tubing is required.

(14) **Material.**—Copper or brass.

(15) **Temper.**—State temper required.
Note.—The regular stock temper of brass and copper tubing is hard. If requiring to be bent, soft or annealed tubing must be ordered.

(16) **Size.**—Give the inside or the outside diameter, and be sure to state whether it is "inside" or "outside" diameter.

(17) **Thickness.** Give the thickness by gauge, and be sure to state the gauge; or give the thickness in parts of an inch; or state whether Iron Pipe size; or send sample.

(18) **Finish.**—Whether Tinned, inside or outside, or both. Other special requirements.

(19) **Quantity.**—Give number of tubes and length each if length is to be exact; or, if exact lengths are not required, give total lineal feet desired and state "in stock lengths."

Note.—Stock length is 12 ft.

Bars for Reinforced Concrete Construction

The following observations apply to material to be purchased for ordinary, miscellaneous construction uses; on large and important work, specifications should be drawn up and tests made by experienced designers and inspectors.

The specifications call for twisted steel bars, as this material answers all purposes of ordinary construction and is quickly and universally obtainable. The author has, accordingly, made it a practice when ordering bars for the use indicated, to confine his specifications to twisted bars, so as to avoid the importunities of salesmen of the patented forms. Otherwise, there can be no objection to requesting the latter to quote on equivalent material.

Quotations are invariably given as a pound-price for stated delivery.

The stock length of bars is about 40 ft., and the mills prefer to supply in lengths of about 18 ft.; but, as a rule, no extra charge is made for cutting a large number to an odd length.

The wire listed is for binding rods, stirrups, etc.

Specifications for Concrete Reinforcing Bars

These bars are to be of steel, made by either the open-hearth or Bessemer process. The steel is to be of "Structural Steel" grade, having an U.T.S. of 55/70,000 lb. and a minimum yield point of 33,000 lb.

The bars shall be twisted cold with one complete twist in a length equal to not more than fifteen (15) times the thickness of the bar.

The material shall be free from injurious seams, flaws, or cracks, and shall have a workmanlike finish.

The material will be subject to rejection if the actual weight of any lot varies more than 5 percent over or under the theoretical weight of that lot.

The rods are to be suitably bundled for (export) shipment, and tagged with shipping marks as per directions of formal order.

List

No.	Description	Size	Length
300	Twisted bars	$\frac{1}{2}$ in. sq.	10 ft. 0 in.
500	Twisted bars	$\frac{1}{2}$ in. sq.	12 ft. 0 in.
100	Twisted bars	$\frac{1}{2}$ in. sq.	20 ft. 0 in.
50	Twisted bars	$\frac{1}{2}$ in. sq.	22 ft. 0 in.
50	Twisted bars	$\frac{5}{8}$ in. sq.	16 ft. 0 in.
50	Twisted bars	$\frac{5}{8}$ in. sq.	20 ft. 0 in.
20	Twisted bars	$\frac{3}{4}$ in. sq.	16 ft. 0 in.

Also Supply

10,000 ft. No. 12 B. and S. soft (annealed) iron or steel wire, black.

Reinforcing Metal Sheets for R. C. Construction

General Information

The two principal **types** of reinforcing sheets are, (1) expanded-metal and, (2) wire fabric of various forms.

Prices are usually quoted on a square foot or 100 sq. ft. basis for a given delivery, the cost varying with the weight per square foot, mesh, etc. A variation in weight of 5 percent, plus or minus, is allowable.

Expanded metal is **shipped** in flat bundles, consisting of a number of sheets wired together and weighing from 200 to 250 lb.; wire fabric in rolls of 150, 300 and 600 ft. lengths (depending on weight).

For ordinary purposes prices may be obtained and **orders placed in two ways:** (1) by consulting the manufacturer's table of standard sizes, listing the material required, and obtaining a price per 100 sq. ft. for a given delivery on this list, or, (2) by submitting a drawing showing the areas to be covered, together with a specification, and requesting a list of material proposed and price per 100 sq. ft. on it. Both methods are described in further detail below.

Expanded metal may be obtained **"black"** (unpainted) or **painted,** wire cloth "black" or **galvanized.** The black material gives a better bond to concrete, but the protected material should be specified for export work, where the sheets are liable to exposure to excessive corrosive conditions.

Ordering Expanded Metal by List

The following table and instructions are taken from the pamphlets of the North Western Expanded Metal Co. Other manufacturers use different systems of designation, but the following list of items will apply to all.

When ordering give: (1) number of sheets required, (2) width, (3) length, (4) area in square inches per 12 in. width, or weight in pounds per square foot, (3) size of mesh, (4) whether painted or unpainted.

"A study of the table of Uniform Standards shows that a consistent plan has been followed. A description of how the meshes are numbered is given under the table.

"When any particular reinforcing area per 12 in. width is wanted simply select the width of mesh and look down that column until a number is found in which the two first figures represent the area wanted. The final figures show the width of mesh. For example, 15–3 means a mesh 3 in. wide having an area of .15 sq. in. per 12 in. width. If it had been 15–6 the area would have been the same, but the mesh would be 6 in.

"The *use of meshes smaller than* 3 *in. is not recommended,* for the smaller mesh costs more per square foot area considered, and cuts up the concrete more than the larger meshes.

Table IV.—Expanded Metal Sizes (N. W. E. M. Co's)

Size of mesh—width					Area sq. in. per 12 in width	Weight lb per sq ft	Elastic limit lb. per 12 in width
½ in	¾ in	1½ in.	2¼ in.	3 in			
Expanded metal numbers							
......	...	....	05–2¼	05–3	.05	.17	3,600
.....	10–¾	10–1½	10–2¼	10–3	10	.34	6,000
......	15–¾	15–1½	15–2¼	15–3	15	.51	9,000
20–½	20–¾	20–1½	20–2¼	20–3	.20	.68	12,000
...	25–¾	25–1½	25–2¼	25–3	25	.849	15,000
...	....	30–1½	30–2¼	30–3	.30	1.02	18,000
...	...	....	35–2¼	35–3	35	1 185	21,000
.	.....	.....	40–2¼	40–3	40	1 36	24,000
Regular lengths—ft.					Stock widths—ft.		
8	8	8	8	8	2, 4, 6, 8		
...	...	......	12	12	2, 3, 4, 6, 8		

"If some certain weight per square foot is wanted look in the column of weights and select the desired weight. Then to the left will be found the numbers to use in ordering, according to width mesh wanted.

"If it is decided to use sheets 3 ft. wide (the most convenient) divide the length of the panel by 2.75 to obtain number of sheets *lapping* 3 *in. on edge.* Add to the total length (width of panel × number of panels), 1 ft. for end bearings. Divide total length by 11.25 to get number of sheets 12 ft. long; or by 7.25 to get number of sheets 8 ft. long. This gives 9 *in. end lap.*

"For sheets 4 ft. wide divide the length of the panel by 3.75. For sheets 6 ft. wide divide by 5.75."

Ordering Wire Fabric by List

Similar tables are issued by the manufacturers of the various types of wire fabrics, from which may be chosen the material having the fineness of mesh and reinforcing area required. The remarks concerning laps may be used also for this material. Care should be taken when specifying sectional area, to state whether area of longitudinal wires only is meant, or total area of both longitudinal and cross wires.

When ordering give: (1) Number of lineal feet, (2) width, (3) style number, (4) area longitudinal wires in square inch per 12 in. width, (5) gauge of cross wires, (6) whether black or galvanized.

Ordering Reinforcing Sheets from Drawings

In cases where steel-frame mill-buildings carry reinforced concrete floor slabs, it is often advantageous to have the contractor for the struc-

ture supply the reinforcing material also, figuring the quantity from the drawings and following a clause in the specifications covering the reinforcing metal. It is usually best to supply a separate drawing showing the areas to be covered.

The specification clause may read as follows:

Reinforcing Metal.—This material is to be of the steel wire cloth type that can be shipped in rolls; expanded metal or other types that must be handled in sheets will not be acceptable. (Auth. Note: This paragraph may, of course, be reversed or altered to suit individual tastes.)

The material is to have not less than .14 sq. in. of metal per foot of width in the main section (*i.e.*, cross-wire areas *not* included), and is to be galvanized.

Enough material is to be supplied to completely cover the areas designated on the drawings, with an allowance of 3 in. for side lap and 9 in. for end lap, and an additional 10 percent for miscellaneous use.

Fire Brick

(1) State service for which the bricks are intended. Some clays yield brick well adapted for certain classes of work but which may be worthless for others; also,

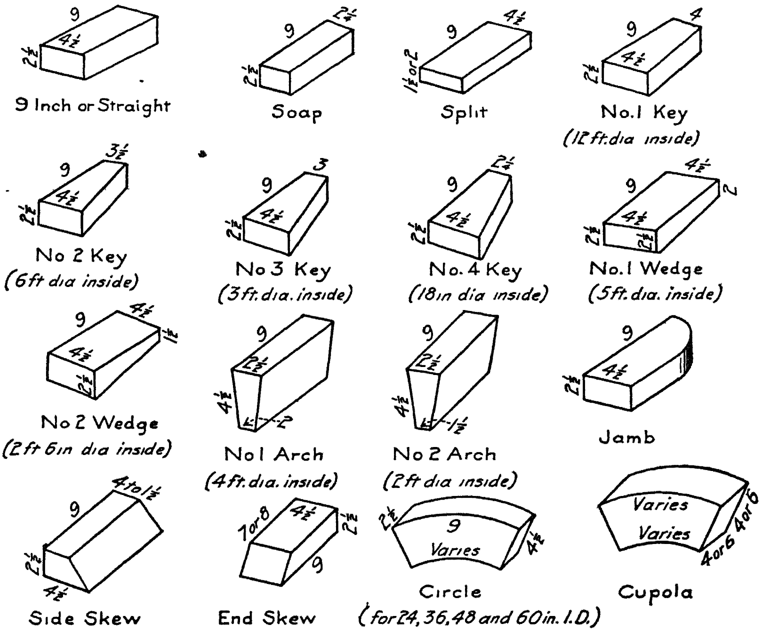


Fig. 56.—Standard fire brick.

manufacturers usually turn out several different qualities or brands; all brick coming from one concern are not necessarily alike in quality. "Furnace" and "Flue" are the usual qualities used for boiler settings.

(2) Ordering.—For straight work and plain arches, order brick by number and name as given in Fig. 56. Tables of circles are given in Tables V to VII.

State whether the amount ordered includes an allowance for spares or not.

For more complicated work, give information as follows:

(a) Foundry Cupolas.—Give inside diameter of shell and size that it is desired to line down to, and height.

(b) Stacks—Same as (a).

Table V.—Showing Number of Arch Bricks Required for Various Circles

Diameter of circle Ft.	In.	No. 2 arch	No. 1 arch	9 Inch	Total
2	0	42	...	...	42
2	6	10	40	...	50
3	0	...	57	...	57
3	6	...	57	7	64
4	0	...	57	15	72
4	6	...	57	22	79
5	0	...	57	29	86
5	6	...	57	37	94
6	0	...	57	44	101
6	6	...	57	52	109
7	0	...	57	59	116
7	6	...	57	67	124
8	0	...	57	74	131
8	6	...	57	82	139
9	0	...	57	89	146
9	6	...	57	97	154
10	0	...	57	104	161
10	6	...	57	112	169
11	0	...	57	119	176
11	6	...	57	127	184
12	0	...	57	134	191

Table VI.—Showing Number of Wedge Bricks Required for Various Circles

Diameter of circle Ft.	In.	No. 2 wedge	No 1 wedge	9 Inch	Total
2	6	60	...	...	60
3	0	48	20	...	68
3	6	36	40	...	76
4	0	24	59	...	83
4	6	12	79	...	91
5	0	...	98	...	98
5	6	...	98	8	106
6	0	...	98	15	113
6	6	...	98	23	121
7	0	...	98	30	128
7	6	...	98	38	136
8	0	...	98	46	144
8	6	...	98	53	151
9	0	...	98	61	159
9	6	...	98	68	166
10	0	...	98	76	174
10	6	...	98	83	181
11	0	...	98	91	189
11	6	...	98	98	196
12	0	...	98	106	204

Table VII.—Showing Number of Key Bricks Required for Various Circles

Diam of circle		No 4	No 3	No. 2	No. 1	9 Inch	Total
Ft.	In						
1	6	25					25
2	0	17	13				30
2	6	9	25				34
3	0		38				38
3	6		32	10			42
4	0		25	21			46
4	6		19	32			51
5	0		13	42			55
5	6		6	53			59
6	0			63			63
6	6			58	9		67
7	0			52	19		71
7	6			47	29		76
8	0			42	38		80
8	6			37	47		84
9	0			31	57		88
9	6			26	66		92
10	0			21	76		97
10	6			16	85		101
11	0			11	94		105
11	6			5	104		109
12	0				113		113
12	6				113	4	117
13	0				113	9	122
13	6				113	13	126
14	0				113	17	130
14	6				113	21	134
15	0				113	26	139
15	6				113	30	143
16	0				113	34	147
16	6				113	38	151
17	0				113	42	155
17	6				113	46	159
18	0				113	51	164
18	6				113	55	168
19	0				113	59	172
19	6				113	63	176
20	0				113	67	180
20	6				113	72	184
21	0				113	76	189
21	6				113	80	193
22	0				113	84	197
22	6				113	88	201
23	0				113	93	206
23	6				113	97	210
24	0				113	101	214
24	6				113	105	218
25	0				113	109	222
25	6				113	113	226
26	0				113	117	230
26	6				113	121	234
27	0				113	126	239
27	6				113	130	243
28	0				113	134	247
28	6				113	138	251
29	0				113	142	255
29	6				113	147	260
30	0				113	151	264

(c) Smoke Flues.—Send sketch of cross-section of flue, taking care to give inside and outside dimensions (or one dimension and thickness), and state length.

(d) Other Work.—For other complicated work, such as for Blast Furnaces, Hot Stoves, Coke Ovens, Kilns, etc., drawing as complete as may be necessary should be submitted.

(3) In cases where order is not placed by number of brick required, state percentage to be added for spare, breakage, etc.

(4) Is any fireclay to be furnished? Amount? Note—Best results are obtained with same kind of clay as is used for brick.

(5) Give directions for shipping. Notes—Minimum carload is 40,000 lb. For shipment by boat, fireclay must be packed in barrels or sacks.
For export shipment fire brick may have to be crated, unless special arrangements are made for handling at terminals. See p. 390

General Information About Fire Brick

From 250 to 350 lb. of fireclay or silica cement is enough to lay up one thousand brick. Fine ground fireclay should be used for laying up fireclay brick, and silica cement for silica brick. In first class brick work, less than 350 lb. of fireclay per thousand brick should be used.

For approximate estimating on fire brick work, use the following figures:

1 sq. ft $4\frac{1}{2}''$ wall requires 7 brick
1 sq. ft. 9″ wall requires 14 brick
1 sq. ft. $13\frac{1}{2}''$ wall requires 21 brick
1 cu. ft. brick work requires 17–9″ straight brick
1 cu. ft. fireclay brick work weighs 150 lb.
1 cu ft. silica brick work weighs 130 lb.
1,000 brick (closely stacked) occupies 56 cu. ft.
1,000 brick (loosely stacked) occupies 72 cu. ft.

Lumber

For abbreviations see p. 513.

Sizes and nomenclature vary somewhat in different parts of the country.

(1) Commercial Sizes

Following are the Standard Dimensions of the Southern Lumber Manufacturer's Association.

Flooring.—The standard of 1 in. × 4 in. and 6 in. shall be 27/32 in. × 6 1/4 in. and 5 1/4 in.; 1 1/4 in. flooring 1 3/32 in.

Ceiling.—3/8 in. ceiling 5/16 in.; 1/2 in. 7/16 in.; 5/8 in. 9/16 in.; 3/4 in. 11/16 in. Same width as flooring.

Finishing.—1 in. S. 1S. or S. 2S to 27/32 in.; 1 1/4 in. S. 1S or S. 2S. to 1 3/32 in.; 1 1/2 in. S. 1S. or S. 2S. to 1 11/32 in.; 2 in. S. 1S. or S. 2S. to 1 3/4 in.

Boards and Fencing.—1 in. S. 1S. or S. 2S. to 13/16 in.

Dimension.—2 × 4 in.	S. 1S. 1E.	to 1 5/8 ×	3 5/8 in.
2 × 6 in.	1S. 1E.	to 1 5/8 ×	5 5/8 in.
2 × 8 in.	1S. 1E.	to 1 5/8 ×	7 1/2 in.
2 × 10 in.	1S. 1E.	to 1 5/8 ×	9 1/2 in.
2 × 12 in.	1S. 1E.	to 1 5/8 ×	11 1/2 in.
4 × 4 in.	3/8 inch off side and edge.		
4 × 4 in.	S. 4S. 1/4 in. off each side.		

"**Framing Lumber**[1] may commonly be purchased in any of the following sizes, except that common pine, spruce and hemlock cannot usually be obtained in larger sizes than 12 × 12 in.

2 × 4	3× 6	4×12	8×12
2 × 6	3× 8	4×14	8×14
2 × 8	3×10	6× 6	10×10
2 ×10	3×12	6× 8	10×12
2 ×12	3×14	6×10	10×14
2 ×14	3×16	6×12	10×16
2 ×16	4× 4	6×14	12×12
2½×12	4× 6	6×16	12×14
2½×14	4× 8	8× 8	12×16
2½×16	4×10	8×10	14×14
			14×16

"In some of the New England Mills, the following sizes are also sawn: 2 × 3, 2 × 5, 2 × 7, 2 × 9, 3 × 4, and 3 × 5. These sizes are not commonly carried in stock, and in most localities would have to be obtained by ripping larger sizes."

(2) **Finish**

Always **specify** on order list the **style of finish** desired; otherwise, in following local trade custom, an entirely unsuitable lot of lumber may be supplied.

The sizes given above (Std. Dimensions of the S. L. Mfrs. Assoc.) illustrate the usual **reduction in dimensions for surfacing.** Note that all dressed lumber is measured and sold on the full size of rough material necessarily used in its manufacture.

Flooring (see above) is always understood, except in New England, to be tongued and grooved.[2] It is S. 1S. and shows 3 1/4 in. or 5 1/4 in., etc., on face after it is laid. In ordering (matched) flooring, therefore, **allowance must be made** for this reduction of covering area.

Ceiling (see above) is S. 1S. for 3/8 in. and S. 2S. for other thicknesses; it is matched and beaded, and shows same face as flooring.

(3) **Lengths**

Standard lengths are multiples of 2 ft. from 10 to 20 ft. inclusive, for boards and strips, and from 10 to 24 ft., inclusive for dimension joists and timbers; longer or shorter lengths than those herein specified are

[1] Kidder's "Architect's and Builder's Pocket Book." John Wiley & Sons, N. Y.

[2] Kidder.

special. Odd lengths, if below 24 ft. shall be counted as of the next higher even length. (S. L. Mfrs. Assoc., 1895). It is, therefore, economical to plan structures so as to utilize even lengths.

However, if timbers are to be finished to exact length ordered (say, for example, 18 ft. 0 in.), it will be necessary to specify particularly in the order that these pieces must not under-run the ordered length, otherwise some sticks may be tendered slightly scant in length.

In ordering **flooring or boards,** it is advisable to allow "random lengths" if possible, as an extra charge is made for a specified length.

In ordering **scantling or planks,** it is advisable to limit the length of 2 in. stuff to 20 ft., 3 in. stuff to 24 ft.

Dimension stock, which may roughly be defined as material 6×6 and up, may usually be obtained in lengths up to 34 ft., and up to 40 ft. at an extra charge.

It should be noted that it is advisable when possible, to **limit to car-load lengths,** or 34 ft.

Spruce, Norway pine, etc., do not run in as large sizes or lengths as yellow pine.

(4) **Miscellaneous Notes**

Short pieces should be "**multipled**" and ordered in standard lengths of from 14 to 24 ft., see Order List below.

When ordering **lumber for buildings,** consult a suitable handbook for material to be specified, finish, percentage to be allowed for waste, etc.

Lagging for concrete forms should, in general, be ordered S. 1S. 2E. for ordinary work; for first-class ceiling surfaces, order matched or ship-lapped lumber; joists and shoring may be ordered rough.

Dimension timber for constructing trestles, bridges, coal-pockets, etc., is usually ordered rough. Dressing lumber, especially on the smaller sizes, reduces very materially the section and strength. It improves the appearance of the structure, however, allows for painting, and enables tighter joints to be made. The additional cost of surfacing on four sides is about $1.00 per M. feet.[1] For stagings, etc., of more or less permanence to be constructed in cities, the material should be ordered surfaced. For the floors of cheap country bridges, the joists and flooring may be ordered rough. For bridge floors of better construction, consisting of two layers of plank separated by tarred paper, order the lower layer S. 2S. and matched, and the upper S. 1S. Hand-rails, etc., for bridges, which have to be painted, order dressed. The timber chords of small highway bridges may be ordered dressed. Derrick timbers order rough. The above examples will give a general idea of the kind of finish to be ordered on construction work.

[1] Jacoby's "Structural Details."

In fixing sizes of **wood members used in connection with steel work,** it should be borne in mind that, while steel will come together exactly as given on the drawing, wood members will under-run in size, will shrink, and must often be sized or fitted, all of which operations tend to reduce the nominal size. The height of shelf-angles, etc., should be adjusted accordingly; and, in ordering wood joists for a highway bridge, the depth should be such that the wood flooring will surely pass over the tops of steel stringers or floor beams without touching them.

(5) **Order List**

In Fig. 57 is given a convenient form of order list for lumber. It will serve both for the lumber man in getting out the material, and also for the carpenter in identifying the items called for on the drawing.

List No. 95 Nov. 26, 1913.

CAMBRIAN ENGINEERING CO.,

NEW YORK CITY.

Contract No. 176.

SILURIAN PAPER CO.

BILL OF LUMBER FOR CONVEYOR IN WAREHOUSE.

Drawing No. 2535.

No. of pieces	Description	Section in in.	Length in ft.	Finish	Cut to length in ft. and in.
15	Post blocks.....	6× 8	12	Rough	28–Pcs. 5 6
50	Stringers...	4×10	20	Rough	48–Pcs 19 11½
40	Posts...........	4× 4	12 (not less)	Rough	36–Pcs. 12 0
100	Side boards	2×10	20	S. 4S.	92–Pcs. 19 11½
....	Sheathing.......	1× 6	1200	S. 2S. T. & G.	Random lengths

All above lumber to be yellow pine, to pass "Merchantable Inspection" of the N. Y. Lumber Trade Association.

FIG. 57.—Order form for lumber.

A certain amount of extra material should be ordered to allow for unsuitable sticks and for waste, say from nothing in the case of a few large pieces to 15 or 20 percent for scantling and plank of good general utility.

CHAPTER V

PURCHASING-OFFICE METHODS AND FORMS

DEFINITIONS OF TERMS "F.O.B.," "F.A.S.," ETC.

A quotation reading **"f.o.b. cars our works"** or simply "f.o.b. our works," means that the manufacturer will, for the price named, deliver the goods "free on board" the cars at his works, taking out the bill of lading but not prepaying the freight on same. The buyer will then receive a "freight bill" from the R. R. Co. when the goods arrive at their destination, and any claim for damage or loss en route must be made by the buyer.

A quotation reading **"f.o.b. our works, freight allowed to Canton, O."** (for example), means that the manufacturer will, in this case also, take out the B/L but will not prepay the freight, leaving this, and the collection of any claims from the R. R. Co., to be done by the buyer at Canton, O. However, in rendering his invoice, the manufacturer will deduct from it the freight charge from his works to the point of delivery; by this means saving himself the trouble of prepaying freight and making any adjustments with the R. R. Co.

A quotation reading **"f.o.b. Canton, O."** (for example, the point of delivery) means that the manufacturer will, for the price named, supply the goods and prepay freight on same to Canton, O., collecting any damages for breakage or loss from the R. R. Co.; *i.e.*, delivering the goods free to the buyer on board the cars at his siding.

A quotation reading **"f.a.s. N. Y. Harbor"** (free alongside steamer N. Y. Harbor, for example) is of the same significance as the last described, except that the R. R. Co. will deliver the material alongside the steamer. The liability of the receivers of the goods in this case is of some interest. If the R. R. has a track on the wharf, its responsibility ends with the running of the cars thereon, and the owners or the steamship company are obliged to unload the goods and place them in the vessel. Or the R. R. Co. may deliver the goods on a lighter alongside the vessel, and it then devolves upon the ship to lift the material, by its own tackle, into the hold. In case the goods are of such weight that they cannot be advantageously handled with the ship's ordinary tackle, the vessel's agents may hire a special derrick-lighter capable of handling the material and may direct the R. R. Co. to place the goods on this lighter and bring the same alongside the vessel.

A quotation reading **"c.i.f. Manila"** (for example) means that the

bid covers "cost, insurance and freight" charges to the port of Manila, and the buyer is supposed to receive his goods on the wharf (or other customary landing place), in good condition and free of any additional expense. It should be noted that the steamship company lifts the material out of the hold and deposits it on the wharf or lighter as part of the freight service. It should further be noted, however, that a quotation "c.i.f." does *not* cover any "landing charges" that may be made at the port-of-entry for lighterage, etc., *nor* does it include customs duties.

Invitations to Bid; General Remarks

Invitations to bid on material or construction may be made, (1) by a letter notifying the prospective bidder of the forwarding to him of plans and specifications, and perhaps, containing information as to when bids should be handed in, place of delivery, and other data that may not appear in the specifications; (2) by a letter that is in itself a specification or brief description of the work required; (3) by standard "invitation to bid" sheets, containing the general conditions in printed form with spaces for the filling-in of the special requirements; and (4) by a printed or typewritten pamphlet, either complete in itself or bound in with the specifications.

The first two methods are the most common, and "reminders" for their proper compilation are given below; the third is used by firms doing a larger amount of business, and its form eliminates very largely any liability to lack of completeness; and the fourth method is usually adopted on work of considerable magnitude, where there will be many bidders, and where the final papers are required in considerable duplication and in more permanent form than is afforded by mere loose papers clipped together.

"Invitation to Bid" Letters

The following "reminders" are intended for use in writing letters of invitation to bid on material or labor (more particularly the former however) in connection with specifications written according to the outlines given in Chap. III. For small jobs several of the items may not be needed, more particularly No. 10, 11 and 12.

Reminders for Invitation to Bid Letters

(1) Notice of enclosure (or of forwarding under separate cover) of plans and specifications, with complete enumeration of the same.
(2) Title of work covered.
(3) Request for price, either "lump sum" or "unit price."
(4) For material delivered f.o.b., c.i.f., etc., at factory, shipping-port, or site of erection; or,
(5) For material erected (give site of erection); or,

(6) For labor to be performed (give site of work).
(7) Material to be packed (for export, etc.).
(8) Time of delivery or erection required; or ask bidder to state earliest convenient (or possible) delivery, with difference in price, if any.
(9) Estimated shipping weight to be stated in bid.
(10) Bids to be submitted by (give date).
(11) Bids to be submitted in duplicate, triplicate, etc.
(12) Certified check required for performance of proposal; conditions of return or retention.
(13) Plans and specifications to be returned with bid.
(14) Terms of payment.
(15) Reservation of right to reject any or all bids.

THE CUBAN-AMERICAN SUGAR COMPANY

No. 107 FRONT STREET

TELEPHONE 6965 BROAD *New York*,.............................

QUOTATION SHEET FOR EXPORT SHIPMENT

.. ..

Dear Sirs:

Please give us your prices (separately on each item) for export to Cuba on material specified below and state **how soon you could deliver** after receipt of order.

Prices must include first class packages and careful packing for land and sea shipment.

Prices must be F. O. B. vessel N. Y. Harbor. All quotations must be given in **Net Prices.**

Req'n No.. . . . . **SPECIFY CASH DISCOUNTS.**

QUANTITY	DESCRIPTION	LIST	DISC.	NET

	Quotation must be in our office not later than........... ....

QUOTATION No. . . . . .

THE CUBAN-AMERICAN SUGAR COMPANY.

RETURN THIS SHEET WITH PRICES NAMED THEREON.

FIG. 58.—"Invitation to bid" blank.

"INVITATION TO BID" BLANKS

These standard forms for obtaining prices on material, etc., are most commonly used by firms who make frequent purchases for export, by large manufacturing concerns who are constantly purchasing a variety of material, by contracting companies, etc. To the first-mentioned they are often necessary to embody special shipping regulations, and to all large concerns they are essential in order to secure uniformity and celerity in clerical operations. When used by a purchasing department with-

out final reference to the engineering department, however, they may be the means of causing much dissatisfaction and delay in the proper filling of orders, on account of the inflexible characters sometimes fixed upon them by the purchasing department.

An example of an "invitation to bid" sheet or "quotation sheet" is given in Fig. 58, and will serve to illustrate the usual style of such blanks.

"Specification Letters"

More calls for prices are made by what may be called "specification letters" than in any other way. When the work in question is a standard article, no trouble may be experienced in obtaining a satisfactory quotation; but when, as is frequently the case, a request for a price on a special and complicated machine, or for a building, or for a complete factory, even, is made on a single sheet of writing paper, a prompt and close tender cannot reasonably be expected.

When no plans or specifications are submitted when asking for prices, therefor, special care should be taken to see that all the important items of the proposition are clearly stated in the letter of inquiry. For preliminary quotations, or for obtaining a price on a standard piece of machinery, a carefully written letter is sufficient without submitting a regular specification, and can be prepared in much less time.

Such a letter should embrace the principal points of the "reminders" enumerated above (p. 213), and also those of the "specification reminders" of the article in question (see Chap. IV). It should be properly headed, and the principal divisions of the specifications should also be accentuated by capitals and underlining. An example of a letter of this class is given below.

HONOLULU IRON WORKS CO.,
29 Broadway
New York City

Dec. 22, 1911.

The Wheeler Condenser & Engineering Company,
90 West Street,
New York City.

Dear Sirs:

Referring to:

Wheeler-Edwards Patent Air Pump for Cane Sugar Factory Use.

In connection with a proposed cane sugar factory on which we are submitting an estimate, we have been asked to give a quotation for the drain pumps for the evaporator on the above type of pump, manufactured by your company. The requirements, operating conditions, etc., will be as follows:

Type.—Steam-driven Triplex (three air cylinders driven by two steam cylinders); each air cylinder for *independent connection.*

Service.—Draining the calandrias of the last three cells of a Standard Quadruple Effect Evaporator concentrating sugar-cane juice; capacity of evaporator 200,000 gallons per 24 hours, 75 percent evaporation by volume.

Capacity.—Each air cylinder is to drain the water of condensation from one cell, this amounting to an average (during the 24 hours) of 26 gallons per minute (theoretical).

Steam Pressure

Maximum 125 lb. per square inch, Working, 60 lb. with 10 lb. back-pressure.

Suction Heads

2nd Cell Pump—Vacuum of about 8 in. maximum.
3rd Cell Pump—Vacuum of about 15 in. maximum.
4th Cell Pump—Vacuum of about 22 in. maximum.
In each case the base of the pump will be about 10 ft. below the evaporator bottom.

Discharge Heads

2nd Cell Pump—10 ft.
3rd Cell Pump—10 ft.
4th Cell Pump—60 ft.

Material Pumped

Water of condensation at 62.3 lb. per cubic foot at temperatures corresponding to above suction heads.
ONE such unit will be required and we ask that you quote us your best export price f.a.s. New York Harbor, packed for export, and also state the approximate shipping weight of the material.

Yours very truly,
HONOLULU IRON WORKS COMPANY
Per

Formal Invitations and Instructions to Bidders

As explained in the introduction to this section, it is usually desirable on important work to have all the papers connected with the letting of the contract prepared in more permanent form than is usual for smaller work. This may be accomplished by having the papers printed and bound in book form. The matter usually included consists of the "Invitation to Bidders," "Instructions to Bidders," blank "Proposal," "Specifications," "Contract," "Index to Specifications" and "Index to Contract."

In this case the "Invitation to Bidders" will consist of a formal invitation, brief description of the work, enumeration of the papers and drawings, terms of payment, reservation as to rejection of bids, etc.; or in other words comprising the information called for on p. 213 of this chapter.

The "Instructions to Bidders" sometimes issued are often barely separable from the "Invitations." They may contain the following directions:

Reminders for Instructions to Bidders

(1) Proposals to be on form furnished, and no changes to be made in the phraseology.
(2) Provisions and directions for alternate proposals.
(3) How and to whom proposals are to be addressed.
(4) Last date on which they will be received.
(5) Return of plans and specifications.
(6) Special notes or instructions.
(7) Reservation as to rejection of any or all bids.

Proposals; General Remarks

Proposals to supply material or to perform work for a consideration may be made

(1) By a letter setting forth briefly the conditions, terms, etc.
(2) On blank forms issued by the owner or his engineers.
(3) On the blank forms of the bidder.

The first method is used by small concerns who do not do a business large enough to warrant the use of special stationery, and also by larger firms engaged in such work, or on such a large variety of work, that their proposal may be better conveyed by letter. Examples of the latter classes are structural-steel fabricators and hoisting and conveying machinery manufacturers respectively. A list of "reminders" for such letters is given in the next article. The second method may consist in the use of the "Invitation to Bid" blanks or "Quotation Sheets," described on p. 214, or in the use of more special "Proposal" blanks for the large jobs. The third method is largely used by firms manufacturing standard machinery, such as engines, boilers, pumps, machine-tools, etc.; for by their use an immense amount of clerical work is saved, and the uniformity and completeness of proposals is secured.

Proposal Letters

The following "reminders" are intended for use in connection with the tendering of proposals for material or labor in cases where blank forms are not used. The omission, due to oversight, in such letters, of information as to "time of delivery," etc., and even of the price itself, is often exasperating to the engineer or owner, and is not infrequently the cause of a rejection of the bid.

Reminders for Proposal Letters

(1) Acknowledgment of receipt of invitation to bid.
(2) Proposal to furnish (or perform)
 (a) material or work as called for in the specifications and plans (enumerated) or,
 (b) material or work as per plans and specifications by the bidder; or
 (c) material or work as described (in this letter).
(3) Delivered f.o.b., c.i.f., etc., at factory, shipping port, or site of erection; or,

(4) Erected (give site of erection); or
(5) (Labor) performed at (give site of work).
(6) Time of delivery, or completion of work.
(7) For sum of (give amount in words and figures); discount, cash (10 days) discount.
(8) Estimated shipping weight.
(9) Terms of payment.
(10) Notice of tendering of certified check.
(11) Notice of return of plans and specifications.

Purchaser's Proposal Forms

An example of a "proposal" form issued by a purchasing firm, in which is also comprised an "invitation to bid," is given in Fig. 58.

For more important work, however, separate and more formal "proposal blanks" should be issued. This is especially true when the work is to consist of a variety of operations upon each of which "lump-sum" or "unit-price" bids are to be obtained, because it is essential that all bidders quote in exactly the same manner on each item. Of such a character, for instance, would be a proposal for the construction of a municipal waterworks, consisting of stripping of the reservoir site, making the earth fill for the dam, placing masonry, etc., etc. The engineer in charge makes estimates of the amount of each item of work involved, and these are given in the proposal form. Bids are then called for on the units of each of these items, the amounts extended, and the totals compiled and compared. Or a lump-sum price may be asked for on an approximate estimate of the quantity of work, and the contractor be required to state a unit-price to take care of work done below or beyond the estimate.

By this means it is insured that all bidders quote on exactly the same quantity of work.

In general, such proposal blanks should cover the following provisions:

Reminders for Purchaser's Proposal Forms

(1) Place and date blanks.
(2) Address to Purchaser; for example, "To the Hilo Railroad Co., Gentlemen:"
(3) Proposal to furnish (or perform) material (or work) in accordance with plans and specifications (designated).
(4) For the amount of, or for the prices (or unit-prices) given in the following schedule.
(5) Blank schedule of work, comprising Item No., Item, Quantity, Total Quantity, Unit Price, Total Price, Unit Price to be deducted for work below estimate, Unit Price for work beyond estimate.
(6) Declaration of complete understanding and examination of plans and specifications.
(7) Declaration of inspection of site.
(8) Agreement as to unit price for work below or beyond estimate.
(9) Method of adjusting charges for extra work, and agreement therewith.
(10) Time within which formal contract will be signed.
(11) Notice of tendering of certified check, and agreement as to forfeiture of same.

(12) Notice of return of plans and specifications.
(13) Declaration of non-collusive bidding.
(14) Declaration of non-participation in profits by any municipal officer.

Reference: Johnson's "Engineering Contracts and Specifications."

Manufacturer's Proposal Forms

In some cases the proposal clauses of a bid are so interwoven with the specification that it is hard to separate them therefrom when wanted. Usually, however, the manufacturer's proposal forms are separate from the specification forms, but of the same size and adapted for binding together with them.

The following "reminders" enumerate the usual provisions, and will serve as a basis for drawing up new proposal forms. The proposal should be well margin-indexed, or each clause should be numbered or lettered so that it may be readily referred to.

Reminders for Manufacturer's Proposal Forms

(1) Heading, name of manufacturer and address, date, etc.
(2) The proposal proper, in form similar to the following: (Name and address of purchaser.)

Dear Sirs:

We propose to sell and deliver to you ——————————— ——————————— for installation at your plant at ———————————.

State of ——————— the following machinery and appurtenances ———————————.

The net price thereof (subject to change at any time prior to your acceptance) to be ——————————— ——————————— Dollars, payable as follows:——————— ——————————— ———————————.

Shipment to be made (contingent upon strikes, fires, accidents or other delays unavoidable or beyond our control) within ——— days after receipt of your acceptance of this proposal.

The above proposal and your acceptance thereof will be subject to the following conditions:

(3) The title to the machinery, and also the right to operate same under Letters Patent controlled by the manufacturer, to remain in the latter until all payments are made in cash; and the purchaser to maintain such title to the seller.
(4) Placing of the machinery on encumbered premises not to affect the title thereto as above provided.
(5) The purchaser to insure the machinery against fire in the amount of (———) until same is fully paid for.
(6) Right to repossess in case of default of payments, the amounts paid to be deemed in compensation for use of the machine and for depreciation.
(7) Compensation for erector, time and expenses; compensation to be continued in case of delays in foundations, etc.
(8) No liability assumed for damages on account of delays or defects.
(9) Replacing of damaged or defective parts within 1 year f.o.b. works.

(10) Proposal for acceptance within ——days.
(11) No promises, agreements, etc., other than contained in this proposal.
(12) The proposal although accepted, is not to constitute a contract until approved by an executive officer of the (manufacturing) company.
(13) Subscription or name of selling firm and signature of agent.
(14) An acceptance form as follows:
Accepted ————191

————————————————

By ————————————————

The above agreement is hereby approved this————————
day of ———————————— 191
BLANK MACHINE CO.
By ————————

Comparing Bids

When bids are received from more than about three contractors, or when a number of alternate bids are called for on a proposition, it becomes imperative to arrange them in tabular form for ready comparison. Figs. 59 and 60 show examples of such tabulations, the first illustrating alternate bids for mill and stock delivery for structural steel work from two contractors; and the second, bids on a large amount of piping which was segregated under four headings for purposes of estimate comparison. These tables may be made in pencil on ordinary paper, a carbon copy being made for the office record, and the original going to the official who decides on the placing of the order. At the same time that the tabulation is compiled, the bid is supposed to be checked against the specifications, and any divergence from them entered under the heading of "Remarks."

Oct. 18, 1913

COMPARISON OF BIDS

Silurian Cement Co. Misc. Extra Steel
Spec. No. 93

No of bid	1	2	3	4
Bidder.	Blank I Wk's	Blank I. Wk's	Ludlow Mfg. Co	Ludlow Mfg Co
Est. sh. weight.	70,000 lb.	70,000 lb.	70,150 lb	70,150 lb
Price	$2,400 00	$2,600 00	$2,467 00	$2,774.00
Price/lb	3.43 c	3 72 c.	3 52 c	3 95 c
Delivery	8 to 9 weeks	about 4 weeks	4½ mo.	2 mo
Remarks	... ..	From stock	.	From stock

FIG. 59.—Form for comparing bids.

Order Letters and Forms

Orders are usually made out on printed forms which give standard directions concerning marking, shipping, invoicing, etc.; typical examples

Cont No. 279
Spec. No. 86

COMPARISON OF BIDS

Apr 21, 1913

Silurian Cement Co.

Steam and Exhaust Lines, Centrif. Press., Etc., Piping

No of bid	1		2		3		4	
Bidder	Cooper Co.		H W. Morgan		Marsh & Hewitt			
	E sh wt.	Price	E. sh wt.	Price	E sh. wt	Price	E sh. wt.	Price
Item "A"	34,000	$2225	31,630	$2667	. .	$2150	. . .	. .
Item "B".	36,000	1845	32,990	1952	. .	2034	. .	. . . .
Item "C"..	21,000	1455	19,830	1718	. . . . .	1901	. . . . .	.
Item "D" .	16,500	859	8,780	817	. . . .	796	. . . .	.
Total .	107,500	$6384	93,230	$7154	. . . . .	$6881	. . . .	. .
Delivery . Remarks .	3 to 4 weeks		. . . . . .		Partial 4 weeks Complete 6 to 8 weeks		. ...	

FIG. 60.—Form for comparing bids.

Order No.....

Telephone 954 John.

CAPE CRUZ COMPANY

133 Front Street

Room 58.

M.............. ....

. .. . New York, N. Y............19..

....

Note.—Advise us at once if any portion of order cannot be filled promptly.

Please furnish for our account, as follows:

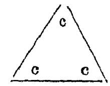
Please number and mark net and gross weight of each package.

Ship by Ward Line S.S.. ....

Shipping Mark

Date. .

MANZANILLO
23 M



No. 1 and up.

Send five original INVOICES and five PACKING LISTS to this office, Invoices must show net and gross weight, number, class and shipping dimensions of each package. Packages containing goods of different classes must have weight separately noted.

CAPE CRUZ COMPANY

Deliver wharf or vessel's receipt to this office.

FIG. 61.—Order form for export shipping.

are given by Figs. 61 and 62, each, however, being for export work and being, therefore, somewhat more exacting than would be required for domestic ordering.

In case orders are placed by letter, the points indicated in these order-forms should be covered.

THE CUBAN AMERICAN SUGAR COMPANY

107 Front Street

Telephone 6965 Broad New York, ... 19..

M.. ....

. . ..

....

Dear Sirs:

Kindly enter our order for goods specified below, in accordance with your quotation of ....

All goods must be securely packed for Land and Sea Shipment.

Invoices and Packing Lists should be forwarded to us on same day material is shipped or delivered.

All Invoices and Specifications to be rendered in quadruplicate.

Invoices must state component parts of each article.

Mark all packages as specified.

MARK

C.S Co.

Cienfuegos, Cuba.
No. 1101 and up.

Yours truly,

THE CUBAN AMERICAN SUGAR COMPANY

Order No.........

Put this No. on your Invoices. ....

FIG. 62.—Order form for export shipping.

A PURCHASING SYSTEM FOR A SMALL OFFICE

General

The **Objects** of the Purchasing Department are

(1) To obtain suitable materials.
(2) To obtain them by a definite date.
(3) To obtain them at fair prices.
(4) To maintain records that will be of the greatest use to itself and to the Cost and Estimating Departments.

The **Schedule** of the Purchasing Department's **operations** are

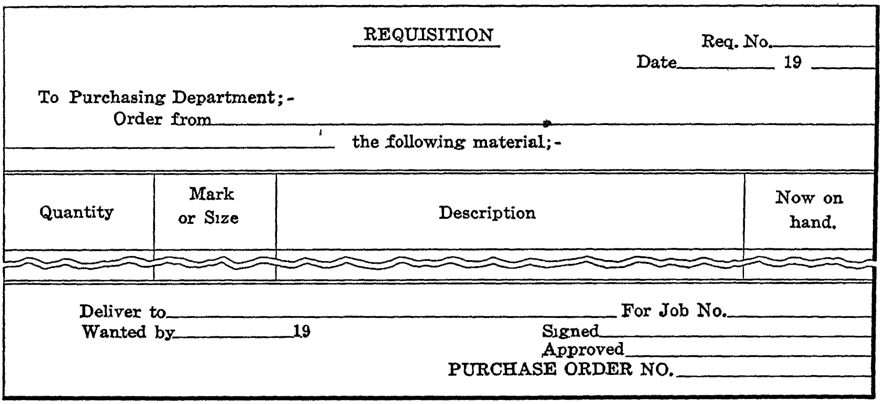
(1) The receipt of requisitions from other departments.
(2) The requesting of quotations from dealers.

(3) The comparison of quotations.
(4) The placing of orders.
(5) The "following-up" of deliveries.
(6) The checking and inspecting of material received.
(7) The checking of invoices or bills of sale.
(8) The recording in suitable form of the above operations.

A brief consideration of each of these operations, with illustrative forms and references more particularly applicable to the small organization (say of a manufacturing jobbing-shop), is given below.

Purchase Requisitions

These are requisitions **issued on** the purchasing department for, (1) material for stock, (2) special material for a particular job, and (3) supplies. The first and last will usually be **issued by** the store-keeper as his stores-ledger or bins show that the supply is getting low, and the


REQUISITION

Req. No.______
Date______ 19 ______

To Purchasing Department; -
Order from______
______ the following material; -

Quantity	Mark or Size	Description	Now on hand.

Deliver to______ For Job No.______
Wanted by______19 Signed______
Approved______
PURCHASE ORDER NO.______

Fig. 63.—Form for requisition on purchasing agent.

second will originate with the planning or engineering department: foremen, as a rule, will not issue such requisitions, but will obtain material needed by an order on the store-keeper.

Fig. 63 shows the **form** that these requisitions usually follow: in cases where a highly organized "Planning Dep't" is in force, more data concerning store schedule-numbers, etc., will have to be provided for.

These forms should be made out **in triplicate,** two copies being sent to the purchasing agent and one remaining on file. The P.A. should check the date of delivery required, and must adjust this matter if necessary with the person issuing the requisition. When the P.A. has filled in the "Purchase Order No." he returns the duplicate copy to the issuer, thus giving him his receipt, and the card or slip should then be passed on to the store-keeper or clerk to be filed with the cards of his perpetual inventory. By their means, the stores clerk can tell immediately what orders are in process of being filled for any particular article.

On the arrival and checking of the material, and its record in the inventory, the requisition slip may be withdrawn, filed away for a period, and then destroyed.

Considering once more the inception of the requisition, the **stores-clerk should be consulted** as to the amount of "material now on hand," so that orders may not be placed for a stock already replete.

It is important that material of different classes be not "bunched" on one requisition; **segregation of items** is imperative where modern stores-accounts and cost-keeping systems are in vogue. The **size of the requisition-sheet** will depend upon the amount of material that will usually be called for on one sheet, and upon the filing system to be followed.

Obtaining Quotations

When **stock material** is to be ordered, such as pipe, bars, etc., the purchasing agent will usually place the business at once at some **discount** from the established list price of which he is constantly kept informed or which can be quickly adjusted.

In the case of **special materials** or machines, however, especially those called for by blueprints and specifications, it will be necessary for the P.A. to obtain bids from several parties by sending out inquiries. The different methods of inquiring for bids, together with "reminders" and forms for procedure, are discussed above under the various headings of "Invitations to Bid."

Standard "Invitation to Bid" blanks will be used in the great majority of cases, and on the office copy may be recorded the **amounts of the various bids,** which is data of considerable use to the cost department. For a further description of a method of recording this data, see the following chapter, p. 228.

Comparing Quotations

This matter is considered in detail on p. 220 in particular reference to complete machines built to drawings and specifications. In the case of standard material, the P. A. is usually able to decide which is the best bid, although this work is becoming more and more an engineering function.

Placing Orders

An example of the usual style of Purchase Order is shown in Figs. 61 and 62. These are usually made in triplicate, the original going to the successful bidder, the second copy being filed serially by order-number, and the third filed alphabetically or topically according to the kind of material covered, thus forming records for the use both of the purchasing and estimating departments.

A **further record** of "orders placed" should be kept in the "perpetual inventory" of the stores department (p. 226). Also, a **list of outstand-**

ing orders, corrected weekly, is usually made, for the convenience of the P.A.

"Following-up" Deliveries

In order that delivery of material may be obtained on scheduled time, or notice of probable delay be promptly and automatically brought to the attention of the departments interested, various systems have been devised.

The **return post-card** is the usual means of obtaining information concerning the progress of the order, and an illustration of such a card is given in Fig. 121. These cards may be filled in at the same time that the order is placed and then filed in a 31-division "tickler" cabinet or in a regular card file with date index, the cards being inserted in dates 2, 3 or 4 weeks ahead of the date of promised delivery, and a batch sent out every day.

Another method consists in the insertion of the promised date of delivery in a **"working schedule,"** to be gone over every day by the schedule clerk, who makes therefrom a list of orders on which deliveries are expected a week or more from date; from this list the P.A. can send out his inquiries.

For a description of the **"tab" method** of "following-up," see p. 440.

Another very simple method consists in filing one of the record **copies of the order itself** in a "tickler" file; first, a few days after date of order so as to obtain a record of acknowledgment, and, second, as far ahead of the promised date of delivery as may be considered advisable to "touch up" the dealer; the copy being retained in the file until the order is filled. In the case of **partial deliveries** this method is particularly useful, for, as the "Receiving Memorandums" (see below) are obtained from the storekeeper, the quantities received can be recorded on the back of the order and the totals carried forward, giving an instant comparison of the completeness of the order. When entirely filled, the order is removed from the "tickler" file and placed in the permanent records.

Checking and Inspecting Material Received

All material entering the stores should be inspected, counted and weighed, and the proper records made of its receipt. For this purpose a **"Receiving Memorandum,"** giving purchase order number, job number, whom from, quantity, weight, description, charges, etc., is useful, to be finally attached to the "purchase order" after the proper comparisons have been made.

Checking Invoices and Shipping Lists

Checking the **Invoice** will consist in comparing it with the figures

on the order, noting discounts, freight charges of all kinds, specified place of delivery, etc.

The matter of checking **Shipping Lists** (more particularly for export shipments) is taken up in considerable detail in the chapter on Export Shipping, see p. 358.

Purchasing Office Records

In the description of purchasing office methods given above, the matter of record-keeping has been constantly referred to. It will be noted that these records are principally for the use of the purchasing, estimating, and stores departments; any other department requiring information on costs of material can obtain it from one or the other of the above-mentioned departments.

Summarizing this matter, we see that the **Purchasing Department** will have on file a copy of the requisition, of the order, of the receiving memorandum and (in some cases) of all the correspondence relating thereto. The **Estimating Department** will have on file, or will have immediate access to, the triplicate copy of the order (filed according to subject), and the "comparison of quotations" sheet; or, if desired, the information thereon contained may be transferred to their cost-data books. The **Stores Department** will retain a copy of the requisition until the order is filled, and will record in their "Perpetual inventory" both "material ordered" and "material received."

THE PERPETUAL INVENTORY

This device will be considered more particularly in reference to **stores accounts.** Its purpose is to tell the stores clerk at a glance the amount (and sometimes the value) of any item in stock, such as structural steel shapes, lumber, castings, bolts, finished parts of machines, complete machines, etc., etc.

The inventory or "stores ledger" is **kept on cards** or on **loose-leaf sheets,** the size of which may be anything to suit the conditions. They may be filed under an alphabetical, topical, or other index as is most desirable. Fig. 64 gives an example of this type of inventory, which may take any variation necessary to the conditions. Its use will be evident from a study of the example.

Its **advantages** are:

(1) It guards against delay in the shop due to waiting for material, for, as the amount of material in stock is posted after every entry, a reduction below the "danger point" is immediately indicated.

(2) It enables material to be reserved in advance for any particular job, with an assurance that such reservation is carried out.

(3) A comparison at intervals with amount of stock actually on

hand will serve to indicate, if shortage is serious and continued, possible peculation.

(4) If values are included in the table, the value of the stock in store is quickly ascertained. This record, also, is convenient to the cost de-

Article Bolts, Machine		**Min.**	100
No. or Size $\frac{3}{4} \times 4$		**Order**	500
Remarks		**Location**	A-5

Date, 1911	Ordered	Order or Job No	Quantity				
			Rec'd	Res'd	Del'd	In stock	
						Res'd	Balance
7/10		Forward					245
7/12		1311			45		200
7/13		1340		100		100	100
7/13	500	R-167					
7/14		1340			50	50	100
7/16		R-167	500			50	600
7/17		1340			50		600

FIG. 64.—Stores card; forming a perpetual inventory.

partment when making estimates on machines which embody parts very nearly like others in stock. This "burden" or overhead rate is usually recorded also, when values are given on the cards.

CHAPTER VI

COST KEEPING AND ESTIMATING

SEC. I. GENERAL AND MISCELLANEOUS

A Cost-data System for a Consulting Engineer's Office

The system outlined below is intended for the use of consulting engineers who are called upon to supply estimates for complete installations, and for engineers engaged in general contracting for such works. In these cases, minute subdivisions of costs are not required, more general results are sufficient, but these results must be reduced to such units, and described with sufficient completeness so that they may be used with adequate certainty in a collective estimate.

The **data collected** will consist of quotations received from manufacturers of machinery or supplies, bids from sub-contractors, records of costs on actual construction, and miscellaneous data appertaining to the line of work pursued.

All **data is kept** in loose-leaf books (see p. 422), the information being first written up and unit results figured by a member of the engineering staff. In general, it may be said that this part of the work cannot be entrusted to a book-keeper or accountant; the value of the record consists in the data being reduced to units that will be immediately applicable to future work, in the statement of the conditions governing the data, and in the logical arrangement and clearness of tabulation employed. When properly started and supervised, however, the clerical work may be intrusted to sufficiently competent subordinates.

A 5 in. × 8 in. **size of sheet** will be large enough in most cases, although some work may demand sheets about 8 in. × 10 in. The size chosen must be the subject of careful advance planning. Different **colored sheets** may be used with advantage, blue for quotations, white for actual contract data, etc. "Heading sheets" should be printed so as to keep such data as "Job No.," "Date," etc., always in the same place. Several copies may be typed at the same time; one set may be filed in a vault (in another building or town) so that the record may be preserved in case of fire, other sets may be sent to branch offices, etc.

Sample sheets, such as were used by a firm of consulting and contracting engineers engaged on sugar-factory installations, are given below (Figs. 65 and 66).

With regard to methods of **indexing and filing,** a system must be chosen that will not become choked or cumbersome with the growth of the data.

EQUIPMENT, Heaters, Juice	FOR, Central Cambria	CONT. No. 116
SUPPLIED BY, Blank & Co.	DATE, Sept., 1909	ITEM NO...
CARD No., 1201, 1205 F.O.B., N. Y. H.	REMARKS, One heater of 2 Bodies	

Heating Surface 600 sq ft. each = 1200 Total.
Size and Type H. I. W. design No. 7, 3 ft. 4 in. inside diameter × 13 ft. 0 in. shell (14 ft. 8 in. O.A. of Heads), 4 in. juice connections.
Material Steel bodies, cast steel Flanges, semi-steel heads and doors, $1\frac{1}{2}$ in. O.D. Copper Tubes No. 16 Stubs Gauge, C. I. Saddles.

Sh. Weight (One body)	9178 lb.
Price (One body)	$1,330
Price/pound	14.5 cents
Price/square feet H. S.	$2.22

Delivery 8 weeks promised; 8 weeks shipped.
Details of Shipment (for 2 bodies)

2 Pkgs	8/12,	17,050 gross	Msmt.	= 612 cu. ft.
2 Pkgs	–/2	1,306	Packing	= 156 lb. = 0 9 percent of Net
4 Total		18,356		
Add for Msmt.		12,240		
		30,596 = (1.67 exact)		

FIG. 65.—Cost data record sheet (white) of completed order.

		EST. No. 1168
EQUIPMENT, Tank, Large	FOR, Central Cambria	Cont. No...
QUOTED BY, Various	DATE, May, 1912	ITEM NO...
CARD No. 2193 F.O.B., N.Y.H.	REMARKS, "Skinned" design	

Size
65 ft. 0 in. diameter × 41 ft. 0 in. high. Covered Molasses Storage Tank
Capacity
1,000,000 gallons.
Description
Bottom of 3/8; Sides of 1/4, 1/4, 3/8, 7/16, 17/32, 19/32, and 11/16 Steel Plates with joints of efficiencies 50, 70, 75, 80, 83, 90 and 90 percent, respectively. Top hemispherical or trussed at option of contractor, ladder, manhole, telltale and nozzles.

No. of Bid	1	2	3	4
Bidder..........	Smith & Co.	J. W. Brown	A. Robinson	T. Johnson
Est. Sh. Wt.......	292,000	322,680	307,080	301,880
Price	$6,600	$7,500	$6,540	$6,400
Price, lb.........	2.26	2 32	2.13	2.13
Delivery..........	60 days	5–6 weeks	6 weeks	
Remarks.........	On Bid No. 3, add for inspection, $30.			

FIG. 66.—Cost data record sheet (blue) of quotations received.

Either the alphabetical as described on p. 413, the "alphabetical with numbered extension" (see p. 414), or some modification of the decimal system (see p. 416) is usually employed. For the smaller offices with well-defined lines of work, the alphabetical system with numbered extension is probably preferable; a comprehensive index must be prepared in advance, but, as explained on p. 415, a revision or extension of this index may be effected without rearrangement of the data. For larger offices, or for offices contemplating a large variety of work, a decimal system may be more suitable; either compiled to suit the special needs, or the Dewey system as extended for engineering uses (see p. 419), or such a system as is described on p. 448.

A cost-data system using sheets as illustrated above, filed and indexed on an "alphabet with numbered extension" scheme, has, in 2 years' time, converted a series of brain-racking guesses miscalled "estimates," into a system giving practically exact costs on large, general make-ups, in a fraction of the time previously expended.

An Estimating System for an Engineering Office

The following estimating system is one that has been developed more particularly for the use of an engineering-contracting office engaged in the design and equipment of large plants in foreign countries. The methods and blanks described will, however, be found applicable to many other estimating conditions. The subject will be taken up under the headings of (1) Indexing and Recording, (2) Compiling, and (3) Filing.

Indexing and Recording

Immediately on receipt of letters, prints, etc., constituting an inquiry, they are stamped with a dating "Received" stamp and are given an **"Estimate Number."** This number may be a continuation of a consecutive series; or, in offices where several thousands of estimates are made every year, it may be a number of a series started at "1" on Jan. 1 of every year, followed by the figures of the year, *e.g.*, "Est. No. 95413" would be the 954th estimate of the year 1913.

A record of the principal features of the estimate is kept in a bound **"Record Book."** The estimate number, date received, owner or agent's (client's) name, subject of the estimate, data received, date required, and final disposition, are all briefly recorded. For a sample sheet see Fig. 67. The data is then turned over to the estimators.

If it is found necessary to submit **separate or alternate quotations** on any estimate which are of such magnitude or importance as to require separate compilations, suffixed letters are attached to the estimate number, and the various different estimates will bear numbers such as "1317-A," "1317-B," etc.

In order that old estimates may be readily found in case inquiries occur concerning them several months or years after their compilation, a **card index system** must be used.

Two indexes are required, one referring to the name of the **"Client"** and the other to the **"Subject."** In each of them the cards had best be filed on an alphabetical system. In case both the owner's and the agent's name occurs, or in case there is any question as to the name of the apparatus, cards should be made out for each possible reference, so that the index may be useful to other people besides the compiler. A sure and simple method of securing this result is for the person in charge of the department to underline in the record book the first syllable of the word for which a card is to be made. An example of a "Client" card is given in Fig. 69 and of a "Subject" card in Fig. 68.

1310			July 12, 1909
N	"Algoma Central," Nuevitas, P. R.; W. G. Dixon and Co., N. Y. Agents.		
S	Increasing capacity of Factory from 1200 to 2000 tons.		
D	List of existing machy. (4p.); four B/p's of present factory; letter from W. G. D. & Co., July 11, '09.		
Req'd	July 24, 1909.	C	July 23, 1909.
Rem.	Tr. to Cont. No. 176, Sept 14, 1909		
1311			July 14, 1909
N	Chihuahua Development Co., Sta Lucrecia, Chi., Mex.		
S	Irrigation Scheme for Mexico; Pumping Machy, etc.		
D	Three maps of district; letter from C. D. Co., Mex. City, July 8, '09; 10p. descr. of scheme, Aug. 13, '09.		
Req'd	July. 25, 1909.	C	Aug. 29, 1909.
Rem.	First data incomplete.		
1312			
N			
S			
D			
Req'd		C	
Rem.			

FIG. 67.—Sample page of estimate record book.

When an estimate is finished and is sent to the Contracting Department, the date is recorded in the "Record Book;" and, in the event that the contract is secured, a reference to its number, or any other useful remark, is also recorded therein.

In order that estimates may be produced on schedule time (usually a matter of the utmost importance), it will be neccessary, when the number of estimates is large, to use a **"Progress Chart"** of some description; an example of such a chart is given in Fig. 73.

Compiling

Methods of taking-off quantities, compiling and using cost data,

etc., in the preparation of estimates, are taken up elsewhere in this chapter.

For compiling estimates and summarizing them into such a shape as will be most convenient to the contracting engineer or other official

SUBJECT	*Factory; Increasing*
	Capacity from 1200 to 2000 tons
NAME	*"Algoma Central," Nuevitas,*
	P. R.; W. G. Dixon & Co., N. Y. Agents
DATE	JUL. 12, 1909
	EST NO. *1310*
	CONT. NO *176*

FIG. 68.—"Subject" card for estimate and contract index.

who puts in the bid, a uniform system of detail, summary and heading sheets should be adopted.

For special lines of work various offices have devised printed blank sheets for **compiling the details** of an estimate, these sheets being frequently quite complicated and entering into minute detail, the object

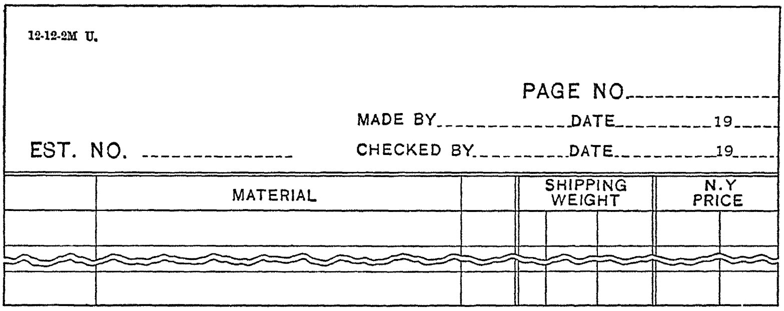
NAME	*"Algoma Central," Nuevitas*
	P. R.; W. G. Dixon & Co., N. Y. Agents
SUBJECT	*Increasing Capacity of Factory*
	from 1200 to 2000 tons
DATE	JUL. 12, 1909
	EST. NO *1310*
	CONT. NO *176*

FIG. 69.—"Client" card for estimate and contract index.

being to avoid omissions and to secure uniformity. For the case in point (general material supply), and for many similar cases, a simple form only is required. An example is given in Fig. 70. This sheet is 8 in. $\times$ 13 1/4 in. in size and is printed on a yellow "pencil" paper.

Bound into pads it is of convenient size and allows carbon copies of the detailed estimate being made if required.

In summarizing weights and prices, it is usually advisable, if possible, not to carry forward results from one sheet to another, as any change


12-12-2M U.

PAGE NO.............

MADE BY............DATE..........19....

EST. NO. ....

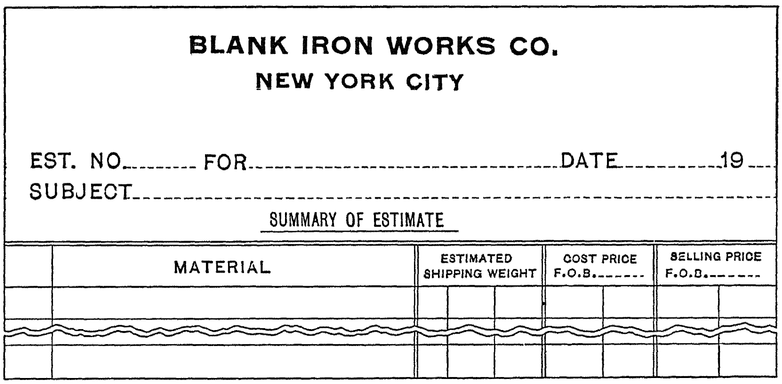
CHECKED BY..........DATE..........19....

	MATERIAL		SHIPPING WEIGHT	N.Y PRICE

FIG. 70.—Example of estimate detail sheet (size, 8 in. wide by 13 1/4 in. high; lines spaced to suit typewriter spacing).

or error has to be carried down the whole line of sheets. A better plan is to **summarize by scheduled classes,** or by pages.

The principal data concerning the estimate, and the summary of the quantities or prices should be set forth on **"Heading"** and **"Summary"** sheets. These should be of a good quality of paper suitable for type-


BLANK IRON WORKS CO.

NEW YORK CITY

EST. NO........ FOR..............................DATE..........19....

SUBJECT..

SUMMARY OF ESTIMATE

	MATERIAL	ESTIMATED SHIPPING WEIGHT	COST PRICE F.O.B.......	SELLING PRICE F.O.B.......

FIG. 71.—Example of estimate summary sheet (size, 8 in. wide by 13 1/4 in. high; lines spaced to suit typewriter spacing).

writing, white or tinted or both (for copies to different departments. etc.). Samples of each are given in Figs. 71 and 72, and are self-explanatory. A copy should be retained by the Estimating Department, and one or more copies sent to Contracting or other departments.

Filing

A convenient method of keeping together all the data of an estimate consists in using folders made of "detail" paper. Such folders, about

BLANK IRON WORKS CO.

NEW YORK CITY

ESTIMATE HEADING SHEET

Est. No.____ Factory________________ Date _____ 19 ___

Owner or Agent____________________________

Estimate for______________________________

Estimate Includes;-_________________________

Estimate does NOT Include;-__________________

Estimate to be presented at ______________ by______ 19 ___

Delivery of material at__________________ by______ 19 ___

Remarks___________________________________

Estimate made by_______________________

7-12 U. 500

Fig. 72.—Example of estimate heading sheet (size, 8 in. wide by 13 1/4 in. high; lines spaced to suit typewriter spacing).

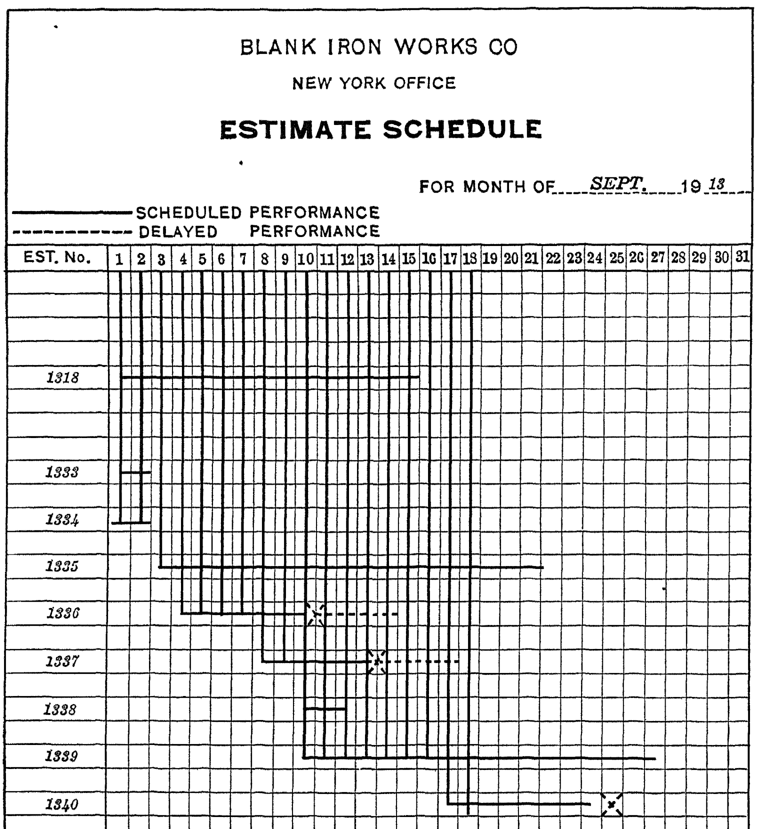


Fig. 73.—Estimate progress chart. Note: Blue and red colors are actually used for "scheduled" and "delayed" performances.

9 in. × 14 in. in size, can be filed (numerically) in an invoice file. The estimate number should be marked on them both on the top and bottom right-hand corner so that a given estimate may be readily located in a file.

With regard to filing the drawings relating to an estimate, practice differs. Some firms regard all such drawings as "correspondence" and file them with the letters and other data of the estimate. Others file them in special "Estimate" drawers similar to others in the drawing office, recording them in the same way as contract prints (see p. 474), and, in case the contract is obtained, transferring the prints and records to the regular contract schedules. The amount and character of estimating done, the drawing-office filing system, etc., will influence the choice of methods.

Estimate-summary Reminder; for Material only

The following reminders are arranged according to no special system; each office has its own method of apportioning "Overhead Expense," for example, and hardly any two methods are alike.

(1) Number of Units.
(2) Material.
(3) Manufacturer's price to us, f.o.b. their works, or otherwise.
(4) Freight Charges, domestic and export.
(5) Drayage and Lighterage.
(6) Insurance (Marine and Fire).
(7) Royalties.
(8) Special Pattern Expense.
(9) Addition or deduction for probable rise or fall in cost of material or labor.
(10) Contingencies.
(11) Drawing Office Expense, direct and indirect.
(12) Overhead Expense, direct and indirect (Subdivide if desired).
(13) Superintendent of Erection; Salary and expenses.
(14) Profit.
(15) Interest on Notes.
(16) Price to Owners, f.o.b. works, f.a.s. shipping port, c.i.f. foreign port, etc.
(17) Agent's Commission, price to agent.
(18) Estimated Shipping Weight and Measurement; give approximate packing list if necessary.
(19) Time of Delivery, f.o.b., f.a.s., etc., from date of final information.
(20) Drawings, sketches, specifications, etc., to accompany bid.

SEC. II. MANUFACTURING COST KEEPING AND ESTIMATING

General Remarks on Cost Keeping and Estimating in Manufacturing Shops

The subject of **Cost Keeping** has received particular attention during the last few years (the engineers having taken up the matter where

the accountants left off) and there is no lack of literature for the man who desires to study the subject with a view to adopting methods in his own establishment.

All that will be given here, therefore, will be an epitome of the more clearly defined principles, and a few practical suggestions applicable to systems for the general jobbing or small manufacturing plant, to the needs of whose management this section is more particularly addressed.

Most of the notations on the subject of Cost Keeping under this and the following heading are condensed from their discussion in "Cost Keeping and Scientific Management"[1] by Holden A. Evans, to which the reader is referred for a very clear and forceful exposition of this subject.

With regard to the matter of Engineering **Estimating,** however, there is very little literature at the disposal of the beginner; and the only book in English of which the author has knowledge is one by "A General Manager" entitled "Engineering Estimates, Costs, and Accounts."[2] This work, while written from English methods, is no less valuable for American practice: extracts made from it in the following pages are suitably referenced.

Cost Keeping is carried out in order that **Estimating** may be done accurately, and also so that the manager may tell where the business stands financially, and also so that waste may be detected and savings pointed to.

The computing of **direct costs** is easy, it is the proper apportioning of the indirect charges that causes troubles.

There cannot be in practice any such thing as a **scientifically correct** cost-keeping system, **close approximations** are the best that can be hoped for, so that any system that may be devised can be readily "torn to pieces" by any competent or incompetent critic; however, the critic's system can also be riddled.

Cost data **should not be kept** by the Cost Dept. **"in glass cases"** as it were; it should be for free distribution among the superintendents, foremen and others who may be connected with or interested in the cost of getting out work. The objections of the Cost Dept. in this matter should be promptly "squelched" by the executive in general control.

Cost data, to justify the expense put on them, **must be kept "up to date;"** otherwise they are of very little use to the estimator; and to the manager none at all.

Engineering estimating involves **two distinct operations,** (1) **Technical,** and (2) **Commercial.** The first embraces the work of the engineer in figuring the weights of the different portions of the proposed

[1] McGraw-Hill Book Co, N. Y., 1911.
[2] Crosby Lockwood & Son, London, 1911.

machine or structure (and sometimes more or less of designing on partly worked-up plans); and the second consists of the work of the accountants in computing the costs from the engineer's data and their own records, and adding the proper profits. Now-a-days, however, both operations are usually conducted by a Cost Department in charge of a technical man.

In preparing estimates on a piece of machinery, etc., dissimilar to anything built before, it will be necessary to **consult the various foremen** and to obtain from them an estimate of the number of men-days and class of labor required on the work. This presupposes, also, that the cost data on shop labor is at the disposal of the foremen; and the example of a cost-keeping system outlined in the following pages was prepared with this procedure in view, as it is in line with the general principle that there is **nothing inherently "sacred" about cost data,** and that its records are intended to advance the general prosperity of the firm above every other consideration.

Notes on Direct and Indirect Expenses in Manufacturing Shops

The fact that the "indirect" expense percentage of cost is increased by any change of method or system is *not* an indication that the shop is less productive; it is the *total* cost of production and not the *direct* cost only that counts.

Many competent managers, however, have found it impossible to bring this fact home to the persons in financial control, and have even had to abandon modern methods in order to reduce a high "overhead" in which the owners could only see unnecessary expenses. There is a vast amount of superficial criticism of large percentage of overhead expense, much of it from persons who have the reputation of being unusually competent business men; and such criticism is usually based on a profound ignorance of analysis of factory costs.

Indirect labor costs may be reduced to a percentage of the machine time, or to a cost per hour of direct labor basis, or to a percentage on the direct cost of labor, etc.; the percentage on direct cost of labor is the easiest and most usual basis for figuring. Thus it would not be right to charge a large percentage on the "material plus labor" cost of an order to a general repair shop, for an injector, requiring only an hour or so's work to install. The cost per hour of direct labor method is more "scientific" than the cost-of-direct-labor method, but involves more clerical work; and the apportioning of indirect charges on the time expended on the machine tool work, while the most accurate and fairest of any, is, at the same time, the most difficult and most costly of application.

A modification of the **"machine rate"** method (as it is called) may sometimes be adopted, in which the largest and least used tools are

charged a predetermined rate for every hour in which they are in operation, their expense being kept separate from that of the rest of the shop. This method is full of difficulties, however, and an attempt to introduce it in the system outlined below was finally abandoned. In certain lines of work, more especially in shops which confine themselves to special processes, such as drop-forging, for example, the "machine rate" method of cost keeping has proved a success. (See "Cost Keeping for Manufacturing Plants" by Sterling H. Bunnell, D. Appleton & Co., N. Y., 1911; and Arnold's "Complete Cost Keeper," Eng. Mag. Press, 1907).

The **direct and indirect labor costs for each department must be kept separate** and separately proportioned; the percentages will vary greatly, and in a general repair shop a general average of indirect charges might be very unfair on many jobs.

The foremen, chief-draftsman, etc., should **assign their time** as far as possible to direct costs, as this is in the direction of accuracy.

"General Expense" jobs should be subdivided as far as desired; *e.g.*, into "Maintenance of Pulleys, Shafting, etc.," "Traveling Crane," etc., so that any undue expansions may be noted and taken care of. Such jobs may be given regular job numbers, 100 or 500 numbers being reserved for them when starting numbering of jobs. Or the numbers may all be prefixed with a 0, as 013, 014, etc.

Where work is done on a "cost plus a lump sum" or a "cost plus a percentage" basis, the inclusion of an overhead charge of more than about 20 percent will usually be combated by the client as excessive. Inasmuch as many successful shops are run with an "overhead" of 100 percent and more, business considerations demand that the **costs be "juggled"** to the client. This can be done by charging, on the job in question, every cost in any way connected with the job (including machine rates) to the direct expense, and letting an overhead of 20 percent or less take care of the remainder.[1]

Below are given indirect percentages taken from an English engineering shop ("Engineering Estimates, Cost and Accounts," see ref. p. 236). While they cannot be directly compared with results derived from data made according to the formula on p. 239, in that they include "general" as well as "departmental" expenses, they nevertheless give a good general idea as to what such indirect percentages may amount to.

"The percentage on direct wages to cover all indirect expenses, both departmental and general, in a general engineering establishment should not exceed the higher rates given in the following scale, while they will not often fall below the lower rates:

[1] Most of the above observations are adapted from "Cost Keeping and Scientific Management;" see ref. p. 236.

Drawing Office	25 to $33\frac{1}{3}$	Percent
Pattern Shop	50 to 75	
D.O. & P.S. when treated as one	$33\frac{1}{3}$ to 50	
Smiths' Shop	75 to 100	
Machine Shop	100 to 150	
Fitting Shop	40 to 50	
Fitters Outside	15 to 25	

It should be borne in mind that such percentages will vary from time to time; and a determination at the end of, say, a year, may be used for next year, or an arbitrary figure, based on the results of a series of years, arrived at.

Formula for Cost Keeping and Estimating for a Jobbing Shop

Below is given, in formulated style, the general scheme of a cost-keeping and estimating system designed for the use of a general manufacturing shop. Also there is given a condensed explanation of the same. Similar tabulations should be made during the installation of any such system so as to maintain a concrete view of the scheme and to ensure its development on proper principles. The example given relates, more particularly, to the system for a jobbing shop described elsewhere in this section.

The item of "Machine Rates" is included to indicate its place in the scheme; it is not further considered for reasons outlined above.

Formula for Cost Keeping and Estimating

Cost of Material: direct $= m$, general $=$ percent $m = m'$, interest on material $= m''$; $m + m' + m'' =$		M
Machine Rates	$=$	R
Mach. Shop Labor: direct $= l$, general $=$ percent $l = l'$; $l + l' =$ ML		
B'smith Shop Labor: direct $= l$, general $=$ percent $l = l'$; $l + l' =$ BL, etc.		
Engrg. and Drafting: direct $= d$, general $=$ percent $d = d'$; $d + d' =$ D		
ML + BL + etc. + D	$=$	K
Estimating $=$ percent K	$=$	E
Office General $=$ percent K	$=$	O
M + R + K + E + O	$=$	T
Business General $=$ percent T	$=$	t
Freight	$=$	F
T + t + F $=$ net cost delivered	$=$	C
Profit $=$ percent C or percent (T + t)	$=$	P
Price Quoted	$=$	Q

Key to Formula Given Above

(M) **Material Costs**

(1) Direct Costs.

(2) Interest on cost of material from payment to payment.

(3) Indirect Cost (computed monthly and expressed as percent of Ml) including:

Purchasing Dept., Inspector and Storekeeper; Rent, Interest, and Depreciation of Bldg. (on yearly percent); Losses and Depreciation of Stock; Miscellaneous.

(L) **Shop Labor.** Note.—All costs to be kept separate for each dept., and denoted as "ML" for Machine Shop Labor, "CL" for Carpenter Shop Labor, etc. This is done so that the proper percent of "indirect" may be assigned to each dept., as they vary greatly.

(1) Direct Labor Cost.

(2) Indirect Labor Cost (computed monthly and expressed as percent of "L1"), including:
Labor on General Expense Job Nos.
Maintenance and Repair on Tools not "machine rated."
Depreciation on same (yearly percent).
Depreciation on Cranes, Shafting, Small Tools, etc. (yearly percent).
Rent or Depreciation of Shop Bldg. (yearly percent).
Power, Heat, Light, etc., for Shop Bldg. (yearly percent).
Supplies, oil, waste, etc. (yearly percent).

(R) **Machine Rates**
An hourly rate on each large or special machine tool used. Rate based on rent, depreciation, power consumed, repairs, etc , the proper corresponding deductions being made from "L2." Rate is constant (*i.e.*, not subject to yearly calculation) but may be changed arbitrarily as comparison with "L2" may indicate.

(D) **Engineering and Drafting**

(1) Direct costs.

(2) Indirect Costs (computed monthly and expressed as percent of "D1"), including:
Work on Standards, etc.
Office Boy.
Supplies, stationery, blue-printing, etc. (on yearly percent).
Rent or Depreciation of Office, etc. (yearly percent).
Light and heat (yearly percent).

(E) **Estimating Dept.** (added as percent of "L + D," computed monthly or yearly), including:
Salaries.
Supplies, etc.

(O) **Office General** (added as percent of "L + D," computed monthly or yearly) including:
Salaries of Manager or Supt , Book-keepers, Time Clerks, Stenographers, etc.
Office Supplies.
Rent or Depreciation, Ins., etc., of Bldg.
Light and Heat.
Miscellaneous.

(t) **Business General** (added as percent of "M + R + K + E + O"), including Expenses of Branch Offices, Traveling Salesmen, Advertising, etc.

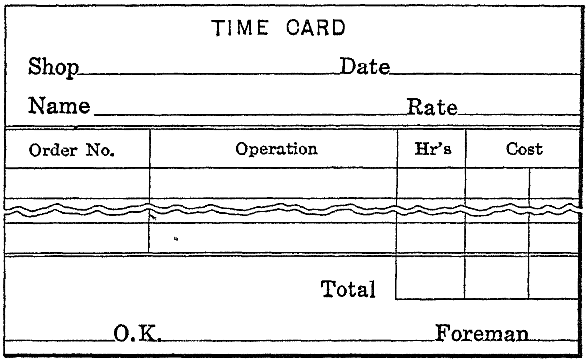
Cost Keeping and Estimating System for a Jobbing Shop

General

The system described below is one which, with slight modifications, was devised by the author for use in a jobbing shop employing about

fifty men. The departments consisted of pattern-making, machine, blacksmith and plate shops, castings being purchased from a nearby foundry under a yearly contract. Almost every kind of rough machinery was fabricated or repaired, although tanks and machines for an industrial specialty formed the principal line of work. The shop had no estimating or drafting department proper, the superintendent, with the aid of an occasional "cub" draftsman, taking care of this part of the work; and the firm possessed a reputation for "doing good work, but for being very erratic in its estimates."

In designing a cost-keeping system for such a shop, the principal object to be attained was, evidently, the collection of records for use in estimating; the system to be the very simplest possible, consistent with sufficiently accurate and prompt results, and provision made for the probable future growth of the company's business. All forms and records, therefore, were designed, primarily, for the use of the estimator, and the system of cost keeping and estimating was moulded to the formula given on p. 239; at the same time, however, the other usual objects of a cost-keeping system were at all times kept in view.


TIME CARD

Shop ______ Date ______

Name ______ Rate ______

Order No.	Operation	Hr's	Cost
	Total		

______ O.K. ______ Foreman

FIG. 74.—Time card; size 5 in. × 4 in.

Workmen's Time Cards

After due consideration of the "job card," the "man-job card" and other systems, the time card illustrated in Fig. 74 was adopted. These cards (or slips) are issued to the men every morning with the date and the department already stamped on them with a rubber stamp, and they are turned in to the foreman every evening for his O.K. The "Rate" and "Cost" columns are filled in by the cost clerk and the results transferred to the Direct or Indirect Labor cost records, as the case may be. For recording Overtime, similar slips are used but of a different color.

All items of "General Expense" are given an Order No. (see p. 238), so that every hour of time is charged against some definite operation.

The cards may be filed or stowed away so that they may be referred to in case of disputes, and those over, say, six months old, destroyed.

Direct Labor Cost Records

The results from the time cards are entered daily against the Job No., each job having a separate "Direct Labor Cost Record" card such as is shown in Fig. 75. The example given is a "heading" card; continuation cards show only the Order No. at the top. "Daily Totals" and "Totals to Date" may or may not be computed daily, or may be computed to date on order, as the Superintendent may desire; it was intended that these figures be used for discussion at the weekly "Foremen's Meeting."

On the completion of the job, the summarized results are transferred to the Summary of Direct Job Cost cards (Fig. 78).

DIRECT LABOR COST RECORD

Ord. No. ..... Client .. . . Year.. ..

Descr.............................. . ... Sh. No. ...... of ....

Date / Shop	D. O.	P. S.	M. S.	B. S.	Pl. S	Daily total	Total to date
Totals							

Fig. 75.—Direct labor cost record card.

Direct Material Cost Records

All material required for a job is obtained by requisition made on the storekeeper by the foreman. These requisition slips (not reproduced) are made out in triplicate, the foreman keeping one for his file and sending two to the storekeeper, who in turn keeps one for his record and forwards the third to the cost-keeping department. The weight of the material is recorded on the latter slips by the storekeeper, and the cost is later added by the cost keeper. Minor material is issued on slips from which, at the end of every week, a formal requisition is compiled. Material not used is returned to store and credited to the job.

As the requisitions come in to the cost department they are recorded against the job on a "Direct Material Cost Record" card such as is shown in Fig. 76, and at the completion of the work the total weight and cost thereon shown is transferred to the Summary of Direct Job Costs card (Fig. 78).

Space in this volume does not permit consideration of the important

matter of store accounts, this being largely, in any event, a bookkeeper's job. It is, of course, extremely necessary that the estimator be furnished with unit material costs; but this information is best obtained from the purchasing agent, whose records should be kept in such a manner as to be of the most use to the estimator: for a discussion of such a system see p. 222.

DIRECT MATERIAL COST RECORD

Job No . . . . . . Client . . . . Year . . .

Descr . . . . Sh No . . . of . . .

Item No	Date	No of pieces	Description	Weight	Costs		
					Unit	Lot cost	Totals
1							
2							
3							
4							
5							
			Totals				

FIG. 76.—Direct material cost record.

Indirect Labor Cost Records

These costs are those on "General Expense" job numbers, maintenance and repair on tools, depreciation on same, rent and depreciation of shop building, power, heat, light, supplies, etc.

These costs are computed monthly, and the ratio between their total and the total "direct labor" cost for the month gives the percentage of "indirect" for the month, care being taken that these costs be kept separate for every department.

A summary of the results of each month's calculation should be typewritten on loose-leaf sheets uniform with those of the Cost Summaries (Figs. 79 and 80), and should be filed with them for ready reference, for it may often happen that special conditions will call for an arbitrary alteration or revision of the "indirect" percentage charge. In general, the results should show at a glance both the percentages for the month for as many months back as the records extend, and also the *percentages to date* for each preceding month, for it is the latter figure which will principally determine the percentage to be used in estimating. An example of such a record is shown in Fig. 77.

Indirect Material Cost Records

These costs may include the salaries of the purchasing agent, store-

keeper, etc.; rent, interest and depreciation on store building and yard; losses and depreciation of stock, etc. These items may be summarized monthly, and results computed and records kept in a manner similar to that described above for Indirect Labor Costs.

Other Indirect Cost Records

Engineering and Drafting "Indirect" may be computed in the same manner as described for indirect labor, obtaining results monthly. The Estimating, Office General and Business General costs (see p. 240) will be computed yearly or half-yearly, and percentages to be used in

INDIRECT LABOR PERCENTAGE

[1] For record of fixed charges see Est. No. 1362 — Dept. Machine Shop

Year and month	Total dir. labor	Indirect expense				Indr % of dir. labor	
		Fixed ch [1]	Supplies	Labor	Total	For month	To date
1913.	15,670	(Carried	forward)		16,500		105 2
Jan	1,020	550	76	632	1,258	123 4	106 5
Feb	974	550	70	510	1,130	116 0	106 8
Mar	1,028	550	62	594	1,206	117 2	107 4
Apr	897	550	55	400	1,005	114 2	107 8

FIG. 77.—Record sheet for Indirect labor percentage. Loose-leaf sheets, 8 in×10 in.

estimating arrived at; and, in their case also, it is important that the figures be recorded in such a way as to show results for each year and *to date*. It is, of course, not necessary that these records be distributed to the estimating department, but a memorandum of the percentages to be used should be supplied to it at intervals.

Summary of Direct Job Costs

On the completion of a job the summary of these costs is recorded on a card arranged as shown in Fig. 78. The object of this record is two-fold: in the first place it is intended for active consultation at any time by any foreman concerned, but, more particularly, at the weekly "foremen's meeting" when an opportunity is thus given to compare estimated with actual costs and to devise ways and means for improved methods in the future; secondly, it is intended for the use of the Estimating Dept. in figuring on work of a similar nature, aided by the advice of the foremen concerned.

The cards should be filed under some Topical Index so that all cards relating to one class of work may be withdrawn for consultation by one motion.

SUMMARY OF DIRECT JOB COSTS.

Job No . . . Customer . . . Date . . 19
No of units . . Description . . .

Total weight . . . lb. Wt each . . . lb
Time . . . Working days . Remarks . . . . . .

DIRECT COSTS

Est cost	Item	Total hours	Direct costs				Foreman's	
			Total	Each	C/hr	C/lb.	Comment	Init.
	Material							
	Labor Eng and dftg. Patt. shop Mach shop B'smith shop Plate shop Misc.							
	Tot. dir. labor							

Sup't's comment. . . . .

FIG. 78.—Summary card for direct job costs; card 9 in. × 9 in.

Final Summary of Job Cost

This summary (made on 8 in. × 10 in. loose-leaf sheets), illustrated by Figs. 79 and 80, is to be accompanied by a third 8 in. × 10 in. loose-leaf sheet on which is pasted a photograph or photographs of the completed work. In conjunction with the card giving the Summary of Direct Job Costs (Fig. 78), it comprises a complete record of the cost of and profit made on the job; and it is intended for the use of the Estimating Dept. Two copies should be made, one for storing in a distant vault, and one for the estimate files. In case the matter of "profits," etc., is attended to by the manager only, a triplicate copy may be made on which this information is entered by himself and the copy filed with his private records.

These records are to be filed in loose-leaf books, on a "topical" arrangement, so that all similar records will be found in one place. Great stress is laid on the necessity of a photograph accompanying the records, as in no other way is it possible to obtain such a clear idea of the character of the job after several years have elapsed, or in case of a change in the estimating force.

FINAL SUMMARY OF JOB COSTS.

Job No. . . .. Customer .. .. .Date 19

No of Units .. .. Description . . . .

....

	Symb	Est	Actual
Direct Costs			
Total Material	M		
Total Labor	L		
Total Direct Costs	TD		
Indirect Costs.			
Material at . . %	m′		
Labor:			
Eng and Drafting at . %	d′		
Pattern Shop at . %	p′		
Machine Shop at . %	ms′		
B'smith Shop at %	b′		
Plate Shop at %	pl′		
Total Indirect Labor	L′		
Estimating at . . % of (L + L′)	E		
Office General at . % of (L + L′)	O		
Total Indirect Costs	TI		

FIG. 79.—First sheet of final summary of job costs, 8 in. × 10 in. loose-leaf sheet

FINAL SUMMARY Job No. ... .

	Symb	Est	Actual
Total Direct Costs	T D.		
Total Indirect Costs	T I.		
Total	T		
Business General at. .. .. . %	t		
Net Cost f o b. Works	C		
Interest on Notes	Int.		
Agent's Commission .... %	Ag.		
Freight to	Fr.		
Extra or Adjustment Costs	X		
Total			
Price Quoted / Sold			
Profit			
Profit % of Net Cost (C)	P		
Unit Figures			
Weight, Total			
Weight, Each			
Cost per lb (Net f o.b. Works)			
Cost per lb . .			
Cost per lb .			
Deliveries			
Remarks			

FIG. 80.—Second sheet of final summary of job costs, 8 in. × 10 in. loose-leaf sheet.

The Estimate Summary

The matter of preparing a detailed estimate on mechanical work is considered on pp. 248 and 249. In conformity with the main purpose of the cost-keeping installation, the "Estimate Summary Sheet" was drawn up on precisely the same lines as the "Final Summary of Job Cost" shown in Figs. 79 and 80, and is itself shown in Figs. 81 and 82.

BLANK IRON WORKS CO.

New York City.

Est No . . . . . . For. . . . . Date . . . . 19 . . . .

Subject . . . .

SUMMARY OF ESTIMATE. Sheet No. 1 of 2.

Item	Symbol	Costs		Totals	
Direct Costs					
Material	M				
Labor:					
Engineering and Drafting	d				
Pattern Shop	p				
Machine Shop	ms				
Blacksmith Shop	b				
Plate Shop	pl				
Misc. (Packing, etc.)	mi				
Total Direct Labor	L				
Total Direct Costs	TD				
Indirect Costs					
Material at . . . . . %	m′				
Labor:					
Eng. and Drafting at . . . . %	d′				
Pattern Shop at . %	p′				
Machine Shop at %	ms′				
B'smith Shop at . %	b′				
Plate Shop at . . %	pl′				
Total Indirect Labor	L′				
Estimating at . . % of (L + L′)	E				
Office General at. . . . % of (L + L′)	O				
Total Indirect Costs	TI				

FIG. 81.—Estimate summary sheet No. 1 of 2; size, 8 in. × 13 1/4 in.

As it was intended that the estimating records be kept and filed in the same manner as that described on p. 230, *et seq.*, wherein *all* the data is filed numerically in paper folders, the sheets were made 8 in. × 13 1/4 in. in size; but under certain circumstances loose-leaf sheets, of the same size as the final cost records (Figs. 79 and 80) but on a differ-

ent color of paper, might be preferable. In the installation here described, "Estimate Heading Sheets" similar to that shown in Fig. 72 were also used.

BLANK IRON WORKS CO.

New York City.

Est No . . For . .. . Date , 19

Subject . . ..

SUMMARY OF ESTIMATE SHEET No. 2 of 2

Item	Symbol	Costs		Totals	
FINAL SUMMARY					
Total Direct Costs	TD				
Total Indirect Costs (. %)	TI				
Total	T				
Business, General at . %	t				
Net Cost f o b. Works	C				
Profit at. . %	P				
Interest on Notes	Int				
Agent's Commission ... %	Ag				
Freight to.	Fr				
Extra or Adjustment Costs	X				
Price Quoted	Q				

Est Weight, one unit lb
Est Weight, total lb.

Delivery at . in weeks from date of final information.

UNIT COSTS (Net f o b Works)
Cost per lb
Cost per . .
Cost per .

FIG. 82.—Estimate summary sheet No. 2 of 2; size 8 in. × 13 1/4 in.

PRACTICAL NOTES ON "TAKING OFF" QUANTITIES IN MACHINE ESTIMATING

Allowance for Finish

In taking-off weights of material shown on drawings where finished sizes are given, additions must be made to these sizes to take care of the weights of the rough material. That such additions may constitute a large percentage of the finished weight will be evident when one remembers that the area of a circular section varies as the *square* of its diameter.

For turning up rolled steel or iron bars into polished shafts, allow 1/16 in. full in diameter up to 3 in.; larger sizes from 1/8 to 1/4.

For round hammered forgings, 1/4 to 3/4 in. On irregular forgings with bosses, etc., allow 1 in. in the diameter for a 6-in. journal size; more for larger shafts.

For a crank forging of about 20 in. throw, allow 1/4 in. all over, and figure shaft and pin holes solid.

For flat parts of machine castings, allow 1/8 in. to 1/4 in.; 1/4 in. O. K. for most surfaces to be turned true, although for poor castings and large pulleys allow more.

Allowance for Castings

In order to allow for fillets and over-run in weight of castings, it is necessary to add a percentage to the net calculated weight varying from 5 percent in the case of large castings to 10 percent in the case of small pieces with numerous fillets.

Table VIII.—Unit Weights of Substances most commonly used in Machinery Estimating

Material	Lb per cu in.	Lb per cu. ft	Remarks
Aluminum, sheet	0.096	166.6	(Molesworth)
Aluminum, cast	0.092	159.8	(Molesworth)
Brass, cast	0.30	520.0	Average
Brass, rolled	0.301	526.8	(Mol.)
Bronze (8 Cu, 1 Sn)	0.305	528.0	(Mol.)
Bronze, Tobin (6 Cu, 4 Zn)	0 302	522 0	(Trade Cat)
Copper, sheets	0 323	558 1	(Trade Cat.)
Copper, cast	0 31	537.3	(Mol)
Gun-metal (8 Cu. 1 Sn)	0 305	528 0	(Mol.)
Iron, cast	0 26	450.0	
Iron, wrought	0 278	480.0	
Lead	0 41	710 0	
Muntz Metal (6 Cu, 4 Zn) (rolled)	0 30	520.0	(Trade Cat)
Rubber	0 034	58.0	(Mol.)
Steel, castings	0.28	484 0	(Trade practice).
Steel, plates and shapes	See	Tables	
Steel, rolled	0 283	490 0	
Steel, tool (carbon)	0 283	490 0	
Steel, tool (high speed)	0.324–0 34	560 0–590.0	(Trade Cat.)
White Metal (Babbett)	0 263	456.3	(Mol.)
Wood, Hard.	5 lb per	ft B M.	
Wood, Soft	3 lb. per	ft B M.	

Detail Sheets

In Fig. 83 is given an example of a convenient form of sheet for recording the details of an estimate. Its use practically compels a certain amount of system in taking off the quantities; so that all plates, all loam castings, etc., will be listed together and cost computed at the proper rate. By preparing the material-estimate in this methodical manner, and by checking-off each piece as listed by a red mark on the print, no serious omissions of items should take place. The same form

may be used for making the estimate of direct labor required; and the totals may then be transferred to the Estimate Summary Sheet (Fig. 81) for addition of Indirect Costs, etc.

SEC. III. STRUCTURAL STEEL ESTIMATING

A Structural Steel Estimating Method

General

The method of "taking off" structural steel material outlined below is one which, with slight modifications, is quite generally used in estimating offices throughout the country. It is submitted, more particularly, as an aid to engineers in other than structural steel offices who may have occasion to make or to check estimates on work of this character. It has been the author's experience that engineers who have never done structural steel estimating quite frequently obtain results

Est. No.________ Made by ________ Date________ 19___

Client________ Chc'kd by________ " ________ 19___

For________

	Material		Weight		at	Cost	

Fig. 83.—Heading of detail sheets for mechanical estimating. Size, 8 in. × 13 1/4 in.

in this work that are 25 percent or more in error (usually low); and that a comparison of their figures with those of the contractor's engineers usually leads to their final discomfiture.

The principal causes of such erratic estimating are, (1) lack of systematic compilation, resulting in gross errors of omission and commission; (2) not allowing a sufficient percentage for weights of details; and (3) forgetting to take off the large number of minor items which often form a considerable percentage of the total weight.

The first deficiency may be met by using a suitable system of taking off and summarizing the quantities, so that results may readily be checked or errors reduced to a minimum; and the object of the following description is to outline such a method. The second source of errors will be dealt with under the heading of "Detail Notes on Structural Steel Estimating" on p. 255; and the third shortcoming may be largely ob-

viated by checking the estimate against a suitable list of "reminders" of the items occurring in the kind of structure being estimated on.

					Boiling House						Est. 34612 Sh. 7	
4		*Trusses*				*Bill*	*for*	*one*				
4	L^s	$2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$	16	9	4 1	2	80					
2			29	3		2	40					
4		$2 \times 2 \times \frac{3}{16}$	2	6	2 5		30					
2			4	6			20					
4			4	9			50					
1			8	6			20					
		Details @	2	5 %		1	60					
		Rivets	6	%			40					
		One	=			8	40					
		4	=								33	60
4	*Cols.*		*Bill*		*for*	*one*						
4	*L*	$6 \times 4 \times \frac{5}{8}$	28	0	20.0	22	40					
1	*Pl*	$14 \times \frac{5}{16}$	28	0	14.8	4	10					
1	*Pl*	$14 \times \frac{3}{4}$	2	0	35.7		70					
2	*L*	$6 \times 4 \times \frac{3}{8}$	1	2	12.3		30					
2			1	0			20					
4	*L*	$6 \times 4 \times \frac{1}{2}$	0	9	16.2		50					
		Riv.					50					
		One	=			28	70					
		4	=								114	80
96	⊔	$7'' \times 9\frac{3}{4}$ #	18	0	*Pl*	168	00					
96		$5 \times 6\frac{1}{2}$	18	0		112	00					
											280	00
8	*I*	20×65 #	18	0	*f*	94	00				94	00
8		$12 \times 31\frac{1}{2}$ #	18	0		45	00				45	00
8		18×55 #	18	0		79	00				79	00
16	*Conns.*	@ 40 #			*Fitt.*	6	40					
16		@ 24 #				3	80					
16		@ 36 #				5	80					
											16	00
											662	40

FIG. 84.—Detail sheet; structural steel estimate (size of sheet, 8 1/2 in. × 11 3/4 in.).

Detail Sheets

A typical example of a detail sheet for a mill-building estimate is shown in Fig. 84. Note that different classes of construction (trusses, columns, etc.) are kept separate; that the purlins, which take web-punching only, are classified separately ("Pl" = punched one face only); that beam-connections are listed separately; and that the page is finally sum-

Made by *W J* Date *June 25'08* Estimate No. *13608*

Checked by ______ Date ______ **BALTIMORE BRIDGE COMPANY** Contract No. ______

Sheet No. *6 of 15*

For *Extension to Bagasse Floor & New Roofing over Stirling Boiler House*

No. Pieces	Size	Wt. per Foot	Length Ft.	In.	Lin Ft.	Weight	Weight	Weight	Weight	Total Weight
	Floor									
7	*I^s 15" R*	42	13	1	91½		F P	R 3843	P	3843
2	*Lines 12" I*	31½	121	0	242		7623			
1	,, *12"* ⊏	20½	142	8	142⅔		2925			10548
	Roof									
10	⊏*s 7"×R*	9¾	15	2	152			1482		1482
15	*Lines 5" P*	6½	55	6	832½				5412	

FIG. 85.—Example of heading for structural steel estimating detail sheet.

Est. *34612*
Sh. *9*

1500	Lin. Ft. #20 G. S. Ridge Roll @ 5#	7,5	00		
	5%	4	00		
				7,9	00
6000	Sq. Ft. #24 G. C. S. Roofing @ 1.3#	7,8	00		
	20%	1,5	00		
				9,3	00
9000	Sq. Ft. #22 G. C. S. Siding @ 1.5#	13,5	00		
	15%	2,0	00		
				15,5	00
6	Sliding Doors @ 400#			2,4	00
12	Small Doors @ 150#			1,8	00
600	Lin. Ft. #20 G. S. Cornice @ 5#			3,0	00
800	Lin. Ft. #20 G. S. Flashing @ 5#			4,0	00
40	Windows @ 100#			4,0	00
20	do. @ 75#			1,5	00
1500	Lin. Ft. ¼" G. Hook Bolts @ 1.6#			2,4	00
500	Lin. Ft. #20 G. S. 8" φ Gut @ 5#			2,5	00
300	Lin. Ft. #20 G. S. 5" φ Leader @ 5#			1,5	00
3	Skylights @ 1000#			3,0	00
				58,8	00

FIG. 86.—Detail sheet: finishing work estimate.

marized. The method of taking-off the material for a bridge or an office-building will differ in no essential feature from the example given, except that, on heavy work it is sometimes required that the angles, plates, etc., comprising a built member, be summarized separately in the several columns provided for that purpose.

A suitable heading for a detail sheet is shown in Fig. 85: note, also, the slight difference in method of taking-off material indicated by the example.

Finishing Iron Work

This material is frequently taken-off by a separate department, especially in the larger offices, but it serves the purpose of this article better to include it in the steel estimate. A typical detail sheet for a mill building estimate is shown in Fig. 86. Note the additions made to corrugated

Sh.No.			Gird.	Col.			15" & Under Pl	Fitt		⊐⊏	18" & Over f	15" & Under f	18" & Over P2	18" & Over P2 M.& Stiff.	Col.	Est. 34612 Sh. 10 Col.
1		7,8 60	23,7 00	3,6 00	3,9 00	3 60	1,42 80	2,4 30	7 20	5,0 00	17,9 50	35,4 00	12,8 00	12,8 00	77,1 00	2,4 00
2		21,6 30		18,0 00		2,1 60	1,0 50	3,4 40	10,4 00		9,4 00	4,5 00				11,4 80
3		18,7 20		21,6 00		2,7 60	38,1 00	2,9 50	11,1 20		7,9 00	39,9 00				13,8 80
4		18,3 60				2,2 70	28,0 00	4,7 00			35,2 50					
5		44,8 90				1,2 00	81,4 30	2,7 00								
6		9,3 00				1,4 40		1,6 00								
7		65,2 80				2,4 00		17,8 20								
8		187,1 50				3,1 00										
		373,1 90				4 00										
						8 00										
						9 60										
						17,8 50										

FIG. 87.—Preliminary summary sheet; structural steel estimate (size, 15 in. wide by 11 3/4 in. deep).

roofing and siding to cover end and side laps; also addition to ridge-roll. Bolts and similar fastenings are always supplied in liberal excess, and should be so estimated.

Summary Sheets

Fig. 87 shows a summary sheet in which the different classes of construction are assembled and totaled separately. For a check on the final weight, a summary is also made by pages (see left-hand end of sheet.)

Fig. 88 shows the summary as finally presented to the cost department for the addition of prices. The necessity for segregation of different constructions will now be apparent, as the "cost per pound" of finished material will vary greatly, depending upon whether trusses, columns, heavy beams, light framed beams, etc., are in question.

Part of the "finishing" material, windows, corrugated steel, etc., will be priced by weight and part by units. As mentioned above, this work is often of so complicated a nature on large work, that a separate department is organized to handle it, making up the estimates, and attending to the drawings and fabrication when the contract is secured.

SUMMARY — Est. *34612* / Sh. *11*

	Girder	*23,7*	*00*
	Col.	*21,6*	*00*
	Truss	*3,9*	*00*
	Strut	*17,8*	*50*
	Bracket	*11,1*	*20*
	Strut	*5,0*	*00*
	Col.	*77,1*	*00*
	Col.	*13,8*	*80*
	15" & under P 1	*81,4*	*30*
	15" & under f	*39,9*	*00*
	18" & over f	*35,2*	*50*
	18" & over P 2	*12,8*	*00*
	18" & over P. 2 M. & Stiff	*12,8*	*00*
	Fittings	*17,8*	*20*
		373,1	*90*
#20	*G. S. Ridge Roll*	*7,9*	*00*
#24	*C. G. S. Roofing*	*9,3*	*00*
#22	*C. G. S. Siding*	*15,5*	*00*
	Sliding Doors	*2,4*	*00*
	Small Doors	*1,8*	*00*
#20	*G. S. Cornice*	*3,0*	*00*
#20	*G. S. Flashing*	*4,0*	*00*
	Windows	*5,5*	*00*
	1/4" φ G. Hook Bolts	*2,4*	*00*
#20	*G. S. Gutters*	*2,5*	*00*
#20	*G. S. Leaders*	*1,5*	*00*
	Skylights	*3,0*	*00*
		58,8	*00*

FIG. 88.—Final summary sheet; structural steel and finishing work.

Other Methods of Summarizing

In some offices it is the custom to present the summaries in greater detail, and two summaries are presented to the cost department. One of these, called the "Material Summary," gives, separately, the weight of beams of different sizes, channels, angles, plates, etc., and opposite each of these the cost of the raw material only is placed. Another summary, known as the "Shop Summary," classifies the material by fabricated weight of trusses, struts, built girders, etc., and opposite these items

is placed the shop cost of fabrication. The total of these two summaries, with the proper additions for "overhead," gives the "gross cost" with somewhat greater exactitude than does the method illustrated in more detail above. The estimating and cost-keeping work is greatly increased, however, and the method is not in general use.

Detail Notes on Structural Steel Estimating

General

Check off each piece on the blueprint when recorded **with red pencil**; when finished, examine plan to see that all beams, etc., have been taken off.

Be careful not to omit whole floors, etc., in the estimate; several floors are often shown on one drawing, and such repetitions are sometimes overlooked.

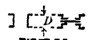
It is **unnecessary to go into refinements** in taking off lengths of pieces, etc.; work to the nearest inch or 3 in ; record weights to the nearest 10 lb.; *accuracy* is required but *not exactness;* be **liberal with weights of details;** a *good* estimate will be 1 or 2 percent *heavy.*

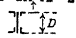
Make **no deduction for corners** cut off, etc., except note that large cut plates may be multipled (see p. 196).

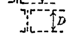
Steel Columns

Column connections for beams weigh in pounds three to two and one-half times depth of beam in inches, according as beam is small or large respectively.

Single lattice take off at 5 lb. per line per vertical foot; **double lattice** at 10 lb.

Splices on Cols.  weigh in lb., 11 times "D" in inches.

Splices on Cols.  weigh in lb., 8 times "D" in inches.

Splices on Cols.  weigh in lb., 10 times "D" in inches.

including splice plates, cap plates, and cap-plate angles.

Classify separately columns of different construction.

Beams

End connections (two 6 × 4 angles) weigh in pounds, complete, twice depth of beam in inches.

Classify separately: (1) beams 15 in. and under, and (2) beams 18 in. and over. Each of these, in turn, should be divided according to whether: (1) punched only in web *or* flange "P1," (2) punched only in web *and* flange "P2," (3) framed (*i.e.*, connection angles on ends and also punched for tie-rods, etc.) "f," (4) coped in addition to framing "c" (distinction against "framed beams" made only on large jobs), and (5) mitred (*i.e.*, bevel cut in web or flange) "M." Note that such classification is not necessary when total weight of job is the only consideration.

Trusses

Material may be taken off from a strain sheet by scaling lengths of main material (using centre-to-centre distances) and adding a percentage of their weight to cover **details and rivets.** The following table gives the percentages which may be added for roof trusses of different proportions.

The percentages for details given in this table cover gusset-plates, fills, and purlin-clips; bracing connections are *not* included (see "Bracing Rods").

The figures given will be found to apply also, with a fair degree of accuracy, to other material of a similar nature, such as light conveyor bridges, riveted bracing, etc.

The figures given for maximum allowable spans for trusses with top chords specified, are based on erection requirements, and pre-suppose the proper bracing of the top-chord by purlins and struts at the usual intervals.

Bridge trusses may be estimated in a similar manner, using percentage obtained from previous estimates or construction; but on large work it is usually requisite to lay out the connection plates and figure their weights, adding a certain amount to cover the inevitable filler-plates, etc.

Top chords	Det	Riv	With top chd. plt.		Max.	Span
			Det	Riv		
$2\frac{1}{2} \times 2 \times \frac{3}{16}$	28 %	7 %			40′	60′
$2\frac{1}{2} \times 2\frac{1}{2} \times \frac{3}{16}$	26	7			60	60
$2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$	25	6			60	60
$3\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$	22	6	14 %	5 %	80	100
$3\frac{1}{2} \times 2\frac{1}{2} \times \frac{5}{16}$	21	5	14	5	80	100
$4 \times 3 \times \frac{5}{16}$	18	5	13	$4\frac{1}{2}$	100	125
$5 \times 3\frac{1}{2}$	16	4	12	$4\frac{1}{2}$	125	150
6×4	14	4	11	$4\frac{1}{2}$	150	200

FIG. 89.—Percentages of weight of main material to be added to cover roof-truss details, etc.

Plate Girders

The stiffeners, end-connections, fillers, etc , may so readily be taken off from the strain-sheet that the percentage method of covering them is inadvisable. Add to cover small fillers, etc., as conditions may indicate, and, finally, add from 6 to 3 percent to cover rivets as work is light or heavy respectively.

Bracing Rods

Add 4 ft. to net length of Loop Rods
Add 7 ft. to net length of Forked Rods
Add 2 ft. to net length of Upset Rods
to cover weight of turnbuckles and nuts.

Also add 15 lb. for each end-connection to truss or column, this weight to be added to summary of truss or column weights respectively.

Tie Rods

1/2 in. at .75 lb. per lin. ft.
5/8 in. at 1.2 lb. per lin. ft.
3/4 in. at 1.7 lb. per lin. ft.
7/8 in. at 2.3 lb. per lin. ft.
1 in. at 3.0 lb. per lin. ft.
These weights will cover nuts and ends.

Hung Ceiling

1 lb. for channels, 1 lb. for angles, 1/2 lb. for fittings (hangers) per square foot
Also add:
Expanded metal .6 lb. per square foot.
Metal lath .5 lb. per square foot.

Mason's Anchors

Terra cotta, plain, 1/2 lb. per square foot.
Terra cotta, elaborate, 3/4 lb. per square foot.
Stone, plain, 1 lb. per square foot.
Stone, elaborate, 1 1/2 lb. per square foot.

Corner anchors, 1 1/2 lb. per vertical foot.
Coping anchors, 1 1/2 lb. per linear foot.
Lining anchors, .1 lb. per square foot.
Carpenter anchors, 1 lb per linear foot of wall.
Carpenter straps, 0.5 lb. per linear foot of girder.

Field Rivets

The percentages given above cover the weight of field rivets, so that no addition need be made to the estimate. The number of field rivets per ton of structural steel will vary between 10 and 100, depending on the class of work; the former figure will apply on heavy, plain office building steel, and the latter on light structural material completely knocked-down for export shipment.

Miscellaneous

Checkered Plate, add for checks, per square foot; steel, 1 lb ; C. I., 2 lb.
Cast Iron, .26 lb. per cubic inch and add 7 percent for fillets and variations.

Estimate Reminder for Structural Steel for an Office, Store, Loft or Similar Building

I. Foundations

(1) **Grillage**
- (a) I-beams, separators (C.I. or G.P.) tie-rods.
- (b) Channels, separators (C.I. or G.P.) tie-rods.
- (c) Rails.
- (d) Built Beam Girders
  Channels and plates (web and flange).
  I-beams and plates (web and flange).
  Stiffening angles.
  Separators, Diaphragm, Bolts, Rivets.
- (e) Plate Girders
  Flange angles, stiff-angles.
  Web plates, Flange Plates, Web-reinforcing plates.
- (f) Riveted Box Girders (two or more webs) (same as (e):

(2) **Bases**
- (a) Cast iron bases.
- (b) Cast steel bases.
- (c) Built steel bases.
  Plates, Angles, Channels, Fills, Rivets.
- (d) Steel slab bases.

(3) **Retaining Wall Framing**
- (a) Bulkhead beams.
- (b) Bottom Reaction-girders; channels, beams, plate-girders, angle.
- (c) Top Reaction-girders; channels, beams, plate-girders, angle.
- (d) Corner framing.
- (e) Tie-backs; Rods, Anchors.
- (f) Reaction Struts; beams, double channels, built struts.
- (g) Tie-rods, anchor-bolts.
- (h) Bracing; Bars, Angles.

(4) **Reinforcing Material**
- (a) Rods.
- (b) Expanded metal.

II. Columns

(1) **Main Material**

(Bsmt — 1) Cols
(1–3) Cols.
(3-n) Cols.
(n-roof) Cols.
Pent House Cols.
Tank Cols.
Elevator Ho Cols.

Channels and Plates.
Channels and Lattice
Channels and Battens.
Beams and Plates.
Z-bars and Plates.
Angles and Plates.
Angles and Lattice.

(2) **Details**

(a) Bases
Base and Wing Plates, Angles, Channels, Fills.
(b) Splices (for each joint).
Plates (flange and web), Cap Plates, Angles, Fill Plates (on smaller col.).
(c) Caps
Cap plates, angles.
(d) Girder and Beam Connections
Basement and Sub-basement.
1st Floor.
Sidewalk Beams.
2nd Floor Beams.
3rd Floor Beams.
nth Floor Beams.
Roof Beams.
Pent Ho. Beams.
Tank Platforms.
Elevator Beams.
Mezzanine Floors.

Angles, Plates.
Fills, Rivets
for
Floor, Spandrel,
Cornice, Etc.,
Beam Connections.

(e) Wind-bracing connections
Angles, Plates, Fills.
(f) Shelf-angles
Plain angles for floor arches, built seats for pilaster supports.
(g) Rivets, percent on total.

III. Floor Framing

(1) **Main Material**

Basement and Sub-basement
1st Floor.
Sidewalk.
2nd Floor Beams.
3rd Floor Beams.
nth Floor Beams.
Roof.
Pent House
Tank Platforms.
Elevator Beams.
Mezzanine Floors.

Beams, Channels.
Double-beam Girder.
Beam Box-girders.
Plate-girders.
Built box-girders.
for
Floor, Spandrel.
Cornice, Skylight Beams.

(2) **Details**

(a) Beam to Beam connections for all above
Angles, Plates, Bent-plates.
(b) Separators and Diaphragms
C.I. and Steel separators, channel or built Diaphragms, Bolts.

(c) Wind Bracing Connections
Angles, Plates.

(d) Shelf-angles; for wood joists, concrete or other arches, for carrying spandrel walls, for taking hooks of wall anchors.

(e) Sidewalk curbs.

(3) **Rivets,** percent on above.

IV. Miscellaneous Framing

(1) **Wind Bracing**

(a) Gusset Plates
Plates, Angles, Fills.

(b) X-bracing
Angles, Channels, Eye-bars, Bars, Plates.

(c) Knee-braces
Angles, Plates, Fills.

(d) Portal Bracing
Plates, Angles, Fills.

(e) Extra long Beam Conns. to Cols.

(f) Lattice Girders
Angles, Plates, Fills.

(g) Rivets, percent on above.

(2) **Spandrel Wall supports, and lintels.**

(a) Carried by Spandrel Beam.
Zs, Angles, Plates, Brackets

(b) Free
Angles, Plates, C. I. Lintels.

(c) Rivets, percent on above.

(3) **Hangers and Posts**

(a) At entrance steps.	
	Angles.
(b) Mezzanine Floors.	Bars.
(c) Miscellaneous.	Posts.

(4) **Stair Framing,** Posts, Hangers, Stringers.

(5) **Elevator Tower Framing**
Bracing, Knees.

(6) **Tank Tower Framing**
Bracing.

(7) **Mullions**
Tees, Angles

(8) **Skylight Framing,** Curbs, etc., Tees, Channels

(9) **Bulkhead Framing** (for Store Windows)
Angles, Tees

(10) **Pipe-space Framing**
Tees, Angles.

(11) **Balcony Framing**
Beams, Channels, Angles, Plates.

(12) **Pent-house Framing** (Walls)
Angles.

(13) **Marqueé Framing,** Beams, Channels, Tie-rods, Bracing, Curbs, Anchors.

V. Fittings

Tie Rods
Wall Anchors
Corner Anchors
Wall Plates
Beam Anchors
Anchor Bolts
Field Rivets & Bolts
Erection Bolts
Smoke Flue & Fastenings
Flagpole & Fastening.

Estimate Reminder for Structural Steel for a Theatre Building

Note.—The following reminders embrace material for the theatre proper only; if offices, etc., are in connection, see reminders for the same, on p. 257.

I. Foundations.
See p. 257.

II. Columns

(1) **Main Material**

Auditorium Wall Cols.	Channels and Plates.
Stage Wall Cols.	Channels and Lattice.
Proscenium Arch Cols.	Channels and Battens.
(to Girder and above).	Beams and Plates.
Other Proscenium Wall Cols.	Z-bars and Plates.
Sub-orchestra Posts.	Angles and Plates.
Interior Auditorium Cols.	Angles and Lattice.
Foyer Cols.	Four Angles (Star Sec.).
Substage Cols.	
Substage Removable Posts.	
Interior Stage Cols.	

2) **Details**

(a) Bases
Base and Wing Plates, Angles, Channels, Fills.

(b) Splices (for each joint)
Plates (Flange and Web) Cap Plates, Angles, Fill Plates (on smaller col.).

(c) Caps
Cap Plates, Angles.

(d) Girder and Beams Connections

Auditorium Spandrel Beams.	
Foyer Beams.	
Orchestra Beams.	
1st Balcony Cantilever.	Angles.
1st Balcony Beams.	Plates.
2nd Balcony Cantilever.	Fills.
2nd Balcony Beams.	Rivets.

Gallery Cantilevers.
Gallery Beams.
Boxes framing.
Auditorium Roof Trusses.
Proscenium Arch Girder.
Proscenium Wall Beams.
Substage framing.
Stage Beams.
1st Fly Gallery Beams.
2nd Fly Gallery Beams.
Gridiron Floor Framing.
Stage Roof Trusses.
Tank Platforms.

(e) Shelf-Angles
Plain angles for floor arches, built seats for pilaster supports.

(f) Rivets, percent on above.

III. Entrance Hall (Foyer) Framing

(1) **Sidewalk Framing**
Beams, Channels, Curb-angles.

(2) **Floor Framing**
Beams, Channels.

(3) **Wall Framing**
Spandrel Beams, Lintels.

(4) **Stair Framing**

IV. Auditorium Framing

(1) **Orchestra Floor Framing**
Beams, Channels, Built Girders, Box Girders, etc., for Orchestra proper, musicians' pit, boxes and side rooms.

(2) **1st Balcony Floor Framing**

(a) Cantilever Girders
Plates, angles, fills, channels, rivets, clips.

(b) Floor Beams
Beams, channels.

(c) Box framing
Beams, channels, bent channels
Built brackets.

(d) Facia Girder
Plates, Angles, Rivets.

(e) Stair Framing.

(3) **2nd Balcony Floor Framing**
Same as 1st Balcony.

(4) **Gallery Floor Framing**
Same as 2nd Balcony.

(5) **Auditorium Ceiling**

(a) Furring Arches
Latticed angles, bent channels, and beams.

(b) Framing beams and channels, plain and bent.

(c) Struts.

(d) Footwalk grills and railings.

(6) **Auditorium Roof**
(a) Trusses
Angles, plates, channels, rivets, clips.
(b) Hangers, to gallery girders
Rods, clevises, turnbuckles, pins, pin-plates.
(c) Hangers to Ceiling
Rods, clevises, etc., and angles.
(d) Purlins
Channels, beams, angles, latticed trusses, braced beams or channels.
(e) Pent House Framing
Angles, channels, beams.

(7) **Elevator Well Framing**
Angles, channels, beams

(8) **Wall Framing**
Spandrel Beams, lintels, etc

V. Proscenium Wall Framing
(1) **Proscenium Girder**
Plates, angles, fills, rivets, clips.

(2) **Proscenium Arch Furring**
(a) Furring Arches
Latticed angles, bent channels and beams.
(b) Connecting framing
Angles, struts, hangers.

(3) **Miscellaneous**
Lintels.

VI. Stage Framing
(1) **Sub-stage framing** (fixed and removable)
Beams, channels.

(2) **Stage-level framing** (fixed and removable)
Beams, channels.

(3) **1st Fly gallery and Dressing-room framing**
Beams, channels, railing, cleats.

(4) **2nd Fly Gallery and Dressing-room framing**
Beams, channels, railing, cleats.

(5) **Paint Bridge framing**
Latticed girder, bracing angles, slat walk, railing.

(6) **Gridiron Floor framing**
(a) Hangers from roof trusses
Angles, flats, end-conns
(b) Main Girders
Plates, Angles, Rivets, Latt. Girder.
(c) Cross Beams
Beams, channels.
(d) Gridiron
Channels, flats.

(7) **Roof Framing**
(a) Trusses
Angles, Plates, Rivets.

(b) Tower for Automatic Damper
Angle Framing.
(c) Purlins
Beams, channels.
(d) Tank Tower Framing
Angles, channels, beams.
(e) Pent House Framing
Angles, channels, beams.

(8) **Elevator Well Framing**
Angles, channels, beams

(9) **Wall Framing**
Spandrel Beams, channels, box girders, built girders, angles, Z-bars, lintels.

(10) **Stair Framing**
Channels, Hanger Angles, etc.

VII. Fittings
Tie Rods.
Wall Anchors.
Corner Anchors.
Wall Plates.
Beam Anchors.
Anchor bolts.
Field Rivets and Bolts.
Erection Bolts.
Smoke Flue and Fastenings.
Flagpole and Fastenings.

Estimate Reminder for Structural Steel Work for a Mill Building

I. Foundation Material

(1) **Bases**
Cast Iron; Cast Steel; Steel Slab.

(2) **Grillage**
(a) I-beams; separators (C.I. or G.P.); tie-rods.
(b) Channels; separators (C.I. or G.P.); tie-rods.
(c) Built Beam Girders
Channels and plates (web and flange).
I-beams and plates (web and flange).
Stiffening angles.
Separators; diaphragms; bolts; rivets.

(3) **Reinforcing Material**
(a) Rods.
(b) Expanded Metal.

(4) **Anchorages**
(a) Anchor bolts.
(b) Washers (Channels, plates).

II. Columns and Posts.

(1) **Main Material** — 4 Angles and Plate.
(a) Main Side Cols. — 4 Angles and Lattice.

Ordinary.	2 Channels and Plates.
For Crane-girders.	2 Channels latticed.
(b) Main Interior Cols.	Plain Beams.
Ordinary.	Star sections.
For Crane-girders.	Two angle posts.

(c) Lean-to Cols.
(d) End Framing Posts.
(e) Floor and Platform Posts.

(2) **Details**
(a) Bases
Base and Wing Plates; Angles, Channels, Fills.
(b) Splices
Plates (flange and web).
(c) Caps
Gusset-plates; cap plates, angles.
(d) Crane Girder Connections
Seat angles; stiffeners; wing plates; fills.
(e) Beam Connections
Seat angles; stiffeners; wing plates; fills.
(f) Siding Clips
Angles.
(g) Bracing Connections
Angles, gussets.
(h) Rivets and Bolts (percent).

III. Trusses

(1) **Main Material**	Channels.
(a) Main Roof Trusses.	Angles.
(b) Lean-to Roof Trusses.	Bars.

(c) Monitor Roof Trusses.
(d) Lattice Girders
Carrying Roof-trusses.
Carrying Crane-runways, etc.
(e)

(2) **Details**
(a) Web Member Connections.
(b) End Connections; wall-plates.
(c) Purlin Clips.
(d) Lateral Bracing Connections (Top and Bottom Chord).
(e) Washers and Fills.
(f) Rivets and Bolts (percent).

IV. Rafters

(1) **Main Material**	I-beams.
(a) Lean-to Rafters.	Two Channels.
(b) Gable Rafters (on side of higher building).	One Channel.
(c) Hip-roof Rafters.	Angle.

(2) **Details**
(a) End Connections
Plates, angles.
(b) Purlin-clips.

(c) Knee-brace connections.
(d) Lateral bracing connections.
(e) Washers and fills.
(f) Rivets and Bolts (percent).

V. Purlins

(1) **Main Material**

(a) Plain Purlins.	Channels, beams, angles, Z-bars.
(b) Stiffened Purlins.	Channels or I-beams with angles and rods.
(c) Lattice Girders	Angles, plates.
(d) Strut Purlins.	
Eave Struts.	Channel and angle.
Peak Struts.	Two channels.
Roof Struts.	I-beam and channel, etc.

(2) **Details.**
Sag-rods.
Rivets and Bolts (percent).

VI. Siding Framing

(1) **Main Material**

(a) Eaves Struts.	Beam, Latt. Angles, Latt. Channels, etc.
(d) Siding Struts.	Channel and Angle, Two Angles, etc.
(c) Girts.	Channels, Angles.
(d) Window Framing.	Channels, Angles.
(e) Door Framing.	Channels, Angles.

(2) **Details**
Sag-rods.
Connections.
Rivets and Bolts (percent)

VII. Crane Girders

(1) **Main Material**

(a) Girders.	Plain Beams, Beam and Channel, Beam and Plate, Beam Box-girder, Built Box-girder, Plate Girder.

(b) Rails
A.S.C.E. or Special section.

(2) **Details**
(a) Girder Splice Plates.
(b) Rail Connections.
Bolts and Clips, Hook-bolts, Splice-plates.
(c) End Stops
Built or Cast, Fastenings.
(d) Rivets (percent).

VIII. Bracing

(1) **Main Material**

(a) Top Chord.	Rods with clevis ends and turnbuckle; rods with nut ends and turnbuckle; plain rods with nuts at end; riveted angles.
(b) Bottom Chord.	
(c) Roof Sway-bracing.	
(d) Monitor Bracing.	
(e) Sides.	

(f) Ends.
(g) Interior.
(h) Knee-braces. Angles, Channels.
(i) Floor Bracing. Angles, Channels.

(2) **Details**
(a) For rod type
Clevises, Pins, Turnbuckles, Nuts.
(b) For riveted type
End connection plates; Splice plates or angles.
(c) Bolts and Rivets (percent).

IX. Floors. (If floors are extensive, see schedule on p. 258).

(1) **Main Material**
(a) Beams, channels, angles, plate girders, box girders, etc.
(b) Checkered steel floor-plates.

(2) **Details**
End connections, shelf-angles, tie-rods, wall plates, wall anchors.

X. Partition Framing

(1) **Main Material**
Verticals; corner posts; girts; window and door framing.

(2) **Details**
Connections; sag-rods; bolts and rivets (percent).

XI. Miscellaneous Framing
(1) Mullions (Main and monitor windows).
(2) Finishing Angles (Main and monitor cornices).
(3) Spacing Angles (Under purlins near wall).
(4) Machinery Brackets.
(5) Shafting Bracket Posts.
(6) Shafting Stringers.
(7) Curb Angles.
(8) Stair Stringers.
(9) Hoppers; Bunkers; etc.
(10) Elevator Framing.

Estimate Reminder for a Steel Truss R. R. Bridge

Note.—If the weight of the details can be obtained sufficiently accurately as a proportion of the weight of the main members, consideration of the same may be omitted in consulting this schedule.

I. Trusses

(1) **Main Members**

Top Chord.	Angles, plates, channels.
Bottom Chord.	Angles, plates, channels, Eye-bars.
End Posts.	Angles, plates, channels.
Int. Posts.	Angles, plates, channels.
Diagonals.	Angles, plates, channels, Eye-bars.
Counters.	Angles, plates, channels, Adjustable Bars.
Sub-verticals.	Angles, plates, channels, Eye-bars.

Sub-diagonals.	Angles, plates, channels, Eye-bars.
Horizontal Struts.	Angles, plates, channels.
Collision Struts	Angles, plates, channels.
End Shoes.	Plates, angles, castings, rails, rollers, sheet lead, bolts.

(2) **Details**

(a) Angles
For diaphragms inside posts at floor-beam connection, Collision-strut connection; End connections of riveted members; Lateral bracing connection at foot of posts.

(b) Gusset Plates (Riveted Bridges only)
Top chord; end posts; bottom chord; sub-members.

(c) Lateral Connection Plates
Top chord; bottom chord; end posts (for portal).

(d) Pin Plates (Pin Bridges only)
Top chord; bottom chord; end posts; int. posts; diagonals; counters; sub-members.

(e) Tie Plates (at ends of compression members)
Top chord; bottom chord; end posts; int. posts; diagonals; counters; sub-members.

(f) Lacing Bars (as above).

(g) Batten Plates (Intermediate Tie Plates) (as above).

(h) Splice Plates
Top chord; bottom chord; for stiff counters.

(i) Fill Plates
Under pin-plates.

(j) Diaphragm Plates
In posts at floor-beam connection; in large chord members.

(k) Cover Plates
At hip, over end-shoe.

(l) Pins and Nuts
Top chord, Bottom chord, for Sub-members.

(m) Washers
At all pins, under end lacing-bars.

(n) Rivets and Bolts
Shop and Field.

(o) Pilot Nuts.

II. **Bracing**

(1) **Main Members**

Top Lateral Struts.	Angles, plates, channels.
Top Lateral Diagonals...	Angles, Adjustable Bars.
Bottom Lateral Diagonals.......	Angles, Adjustable Bars.
Bottom Lateral End Struts	Angles, channels, plates.
Portal Struts.	Angles, plates, channels.
Portal Webbing	Angles, plates.
Portal Knees....	Angles, plates.
Sway-brace Struts	Angles, plates, channels.
Sway-brace Diagonals..........	Angles, Adjustable bars.
Sway-brace Knees	Angles, plates.

(2) **Details**

(a) Angles
Top lateral and sway-brace struts to posts.

Portals to end posts.
Knee-braces to posts.
Bottom lateral angles to stringers.
Diagonal end-connections.
Diagonal-angle splices.
End connections of rods.

(b) Gusset Plates
Portal members, sway-brace members, knee-brace connections.

(c) Tie Plates (At ends of compression members)
Lateral struts, lateral diagonals, portal bracing, sway-brace members, knee-braces.

(d) Lacing Bars
Same as for (c).

(e) Splice Plates
Lateral diagonals, web plate splices.

(f) Fill Plates
On single-lacing tie-plates.

(g) Pins and Cotters
Top laterals, sway-brace diagonals

(h) Washers

(i) Rivets and Bolts.

III. Steel Floor System

(1) **Main Members**

End Floor Beams.	Angles, plates, beams.
Intermediate Floor Beams. .	Angles, plates.
Stringers..	Beams, angles, plates.
Stringer Bracing.	Angles.
Solid Floor.	See p. 272

(2) **Details**

(a) Angles
End connections of floor-beams to posts.
End connections of floor-beams to brackets.
Erection seats and stiffeners on floor-beams.
End floor-beam connection to end-post.
End connection of stringers.
Stringer stiffeners.

(b) Gusset Plates
Stringer bracing.

(c) Splice plates
Floor-beam webs to end plates.

(d) Reinforcing Plates
At ends of stringers, at stringer connection on floor-beam, at ends of floor-beams.

(e) Fill Plates
Under stringer stiffeners and end angles.
Under floor-beams, end plates and angles.

(f) Base Plates
For end stringers.

(g) Rivets and Bolts
Shop and Field.

IV. Track Material and Miscellaneous

Standard floor bolts.

Hook bolts.
Washers (Standard and special).
Guard-rail angles.
Name-plate and fastenings.
Erection bolts.

Estimate Reminder for a Steel Truss Highway Bridge

I. **Trusses**
See Outline for "Steel R. R. Bridge" (p. 266).

II. **Bracing**
See Outline for "Steel R. R. Bridge" (p. 267).

III. **Steel Floor System**

(1) **Main Members**
End Floor Beams (Angles, Plates, I-beams, Channels).
Intermediate Floor Beams (Angles, Plates, I-beams).
Track Stringers (Beams, Angles, Plates).
Road and sidewalk stringers (beams, channels, angles, plates).
Solid Floor (see p. 272).
Sidewalk Brackets (Angles, Channels, Beams, Plates).
Stringer Bracing (Angles, Flats).

(2) **Details**
(a) Angles
End Connections of Floor-beams to Post.
End Connections of Sidewalk Brackets to Post.
Erection Seats and Stiffeners on Floor beams.
End Floor-beam connection to end post.
End Connections of stringers.
Stringer Stiffeners.
Sidewalk Bracket Details.
(b) Gusset Plates
Stringer Bracing.
Sidewalk Bracket Details.
(c) Reinforcing Plates
Ends of Stringers, at Stringer connection on Floor-beam, at ends of Floor-beams.
(d) Fill Plates
Under Stringer Stiffeners and End Angles.
Under Floor-beam Stiffeners and End Angles.
(e) Base Plates
For End Stringers.
(f) Other Plates
Floor-beam Hangers, Floor-beam Rod-hanger Washer Plates.
(g) Bars
Floor-beam Hangers.
(h) Tie Rods
For Stringers (with concrete arches).
(i) Rivets and Bolts
Shop and Field.

IV. **Miscellaneous Fittings**
- Standard Floor Bolts (for Guard Rails, Hub Rails, Spiking Pieces).
- Hook Bolts (For Trolley Rail Cross-ties)
- Washers (Standard and Special).
- Hand Rail and Connections.
  - Plain for Trolley Side.
  - Ornamental for Sidewalk Side.
- Cast-iron Ornaments, Portal, Bosses, Knee-brace, etc.
- Name Plate and fastenings.
- Erection Bolts.
- Curb angles on guard rails.

V. **Lumber**
- Trolley Stringers.
- Floor Stringers (Main and Sidewalk).
- Floor Spiking Pieces (Top or Side).
- Trolley Cross-ties
- Floor joists.
- Flooring for Roadway.
  - First course, finishing.
- Flooring for Sidewalk.
  - First-course, finishing.
- Guard Rails.
- Hub Guards.
- Hand-rail Posts.
- Hand Rails, Top and intermediate.

Estimate Reminder for a Deck Plate-girder R. R. Span

(1) **Girders**
- (a) Angles
  Top flange, bottom flange, end stiffeners, intermediate stiffeners, flange splices, cross-tie seats
- (b) Plates
  Web, web splices, cover-plates (top and bottom), side flange plates (top and bottom), flange splices, base plates, web reinforcing.
- (c) Fill Plates
  End stiffeners, int. stiffeners, cross-tie seats.
- (d) Rivets and Bolts
  Shop and field.

(2) **Lateral Bracing (Top and Bottom)**
- (a) Angles
  Diagonals, struts, end connections of diagonals.
- (b) Plates
  Gussets, fills.
- (c) Rivets and Bolts
  Shop and field.

(3) **Sway Bracing (Cross Frames)**
- (a) Angles
  Intermediate Frame diagonals and struts.
  End Frame diagonals and struts
- (b) Plates
  Gussets at corners and center of sway-brace frames, fill-plates.

(c) Rivets and Bolts
Shop and field.

(4) **Fittings**
(a) End Bearings (Fixed and Expansion)
Base plates, rails, rollers, castings, pins, steel shoes, anchor-bolts, connection bolts, guide plates, rivets.
(b) Track Material
Standard floor bolts, hook-bolts, washers (standard and special), guard-rail angles.
(c) Name Plates and Fastenings.
(d) Erection Bolts.
(e) Hand-rail and attachments (for trestles only).

Estimate Reminder for a Through Plate-Girder R. R. Span

(1) **Girders**
(a) Angles
Top flange, bottom flange, end stiffeners, intermediate stiffeners, curved flange angles at ends, flange splices, solid floor connections, solid floor finish.
(b) Plates
Web, web splices, web reinforcing, cover plates (top and bottom), side flange plates (top and bottom), flange splices, base plates
(c) Fill Plates
End stiffeners, intermediate stiffeners, solid floor connections.
(d) Rivets and Bolts
Shop and field.

(2) **Floor beams (End and Intermediate)**
(a) Angles
Top flange, bottom flange, bracket, stringer erection seat.
(b) Plates
Web, web reinforcing, web splice, bracket, reinforcing plate at stringer connection, fill plates under bracket angles, other fill plates.
(d) Rivets and Bolts
Shop and field.

(3) **Stringers**
(a) Angles
Top flange, bottom flange, end connections, stiffeners, stringer bracing.
(b) Plates
Web, web reinforcing, flange cover plates, fill plates under stiffeners and end connections, stringer bracing gussets.
(c) Rivets and Bolts
Shop and field.

(4) **Lateral Bracing**
(a) Angles
Diagonals, connections to stringers, end of diagonals, splice angles.
(b) Plates
Gussets (to girders), splice plates, fills under gussets, connections to stringers.
(c) Rivets and Bolts
Shop and field.

(5) **Solid Floor**
- (a) Angles
  For rectangular-built troughs, end connections.
- (b) Plates
  For rectangular-built troughs; for Z-bar troughs.
- (c) I-beams
  For concrete, wood, buckle-plate, etc., floors.
- (d) Z-bars
  In connection with plates.
- (e) Channels
  For "hung" floors.
- (f) Buckle-plates.
- (g) Trough Sections.
- (h) Fill plates; splice plates (for buckle-plates), etc.
- (i) Concrete Reinforcement; bars, metal, wire.
- (j) Rivets and Bolts
  Shop and field.

(6) **Fittings**
- (a) End Bearings (Fixed and Expansion)
  Base plates, rails, rollers, castings, pins, steel shoes, anchor-bolts, connection bolts, rivets, guide plates.
- (b) Track Material
  Standard floor bolts, hook bolts, washers (standard and special), guard rail angles.
- (c) Name Plates and Fastenings.
- (d) Erection Bolts.

Estimate Reminder for a Steel R. R. Trestle

I. **Girders**

See outline for Deck-plate Girder Spans (p. 270), or Through-plate Girder Spans (p. 271).

II. **Trestle Bents (Single or in Tower)**

(1) **Main Members**

Posts	Channels, I-beams, plates, angles
Hor. Struts, Top, bottom and intermediate	Channels, angles, plates.
Transverse Diagonals	Angles, rods, channels, plates.
Sub-verticals	Angles, rods.
Shoes (for Rocker Bents)	Angles, plates, pin.

(2) **Details**
- (a) Angles
  Tops of posts, bases (connection to plate and for anchor-bolt bracket), pin connections, end connections of struts and diagonals.
- (b) Gusset Plates
  For transverse and longitudinal bracing (riveted and pin connections), strut connections.
- (c) Pin plates
  At bottom of rocker-bent posts, rod bracing connections.
- (d) Tie Plates (At ends of compression members)
  At ends of posts and struts, and at panel-points.

(e) Batten Plates (Intermediate Tie-plates)
For posts, struts, riveted diagonals.
(f) Lacing Bars
For posts, struts, riveted diagonals.
(g) Splice-plates
Main posts, intersections of diagonals.
(h) Fillplates
Under pin-plates, in shoes, ends of riveted members.
(i) Cover Plates
Tops of posts.
(j) Pins and Nuts
For transverse bracing and bottom of posts.
(k) Washers
At all pins, under ends of lacing-bars.
(l) Rivets and Bolts
Shop and field.
(m) Pilot Nuts.

III. **Longitudinal Bracing**

(1) **Main Members**

Horizontal Struts, top, bottom and intermediate.................. . . .	Channels, angles, plates.
Diagonals.	Angles, rods, channels, plates.
Sub-verticals...	Angles, rods.

(2) **Details**
(a) Angles
End connections of struts and diagonals.
(b) Tie Plates (At ends of compression members)
Ends of struts.
(c) Batten Plates (Intermediate Tie Plates)
For Struts, riveted diagonals.
(d) Lacing Bars
For Struts, riveted diagonals.
(e) Splice Plates
At intersection of diagonals.
(f) Fill Plates
At ends of riveted members.
(g) Pins and Nuts
For rod longitudinal diagonals.
(h) Washers
At all pins, under end lacing-bars.
(i) Rivets and Bolts
Shop and field.

IV. **Fittings**

Anchor-bolts, top and bottom washers for anchor-bolts. Erection Bolts. C. I. pedestals at top of posts (for spans on grades).

SEC. IV. CONSTRUCTION COST KEEPING AND ESTIMATING

Classification of Construction Contracting Costs

The classification scheme given below is intended to afford a "bird's eye view" of the field of construction costs, for the clarification of ideas, and as a basis for cost-keeping and estimating schedules.

Formula

Direct Costs:

Labor	La.
Material	Ma.
Sub-contracts	S.-C.
Plant	Pl.
La. + Ma. + (S.-C.) + Pl. =	Dir.

Indirect ("Percentage" Costs)

Supplies	Sup.
Bond and Ins.	Bo.
Interest	Int.
Miscellaneous	Mi.
Contingencies	Con.
Commissary	Com.
Overhead	Ov.
Sup. + Bo. + Int. + Mi. + Con. + Com. + Ov. =	Ind.

Profit (percent La + percent Ma. + percent S.-C + percent Pl. + percent Ind.) = Pr.

Check: Pr ÷ (Dir. + Ind.) × 100 = ?

Elaboration of Expense Items

(La.) **Labor Costs**

Clearing and grubbing
Excavation
Form Building, Sub-structure
Form Building, Super-structure
Pile Driving
Placing Steel
Concreting, Sub-structure
Concreting, Super-structure
Concreting, etc., etc.; also:
Constructing temporary roads, tracks, buildings, etc.
Shifting plant from point to point.

(Ma.) **Material Costs** (Cost delivered on job; or cost f.o b. with hauling charge under "Mi").

Steel, Cement, Sand, Stone, Lumber, Piling, Brick, Rubble.
Railing, Dr Pipe, etc , etc.
Includes only such material (together with wastage) as goes into the finished structure.

(S.-C.) **Sub-contracts**

Excavation, Roofing, Plumbing, Elevators, Painting, Elect. Fixtures, etc., etc.

(Pl.) **Plant.**—(First cost or invoiced value charged to job; sale price or invoiced value at completion credited to job; or, if machinery is considered as an investment, add for interest or rental; if as an expense item, charge depreciation to job direct)

Pile Driver, Concrete Mixer, Steam Shovel, Stone Crusher, etc.; also Temporary Office and Shop Buildings, Trestles, Falsework, Bracing, Forms, Housing Plant in Winter, etc.

(Sup.) **Supplies.**—(A direct charge against each job. Either estimated, or, if records are available, figured as a *percentage of the labor cost.*)

Includes all such items of material as are necessary to the carrying on of the work, but which are partially, or wholly, destroyed in the process of construction. Percentages will be fairly uniform for *any class* of work, but will vary widely for *different* classes.

(1) **Petty Tools.**—Spades, hammers, bits, anvils, trucks, jacks, chains, etc. Example.[1] varies from 1.8 to 2.6 percent of labor cost.

(2) **Fuel and Oil.**—Coal, gasoline, engine-oil, waste, etc. Example:[1] varies from 1.4 to 7.2 percent of labor cost.

(3) **Fittings and Repairs.**—Asbestos, babbit-metal, valves, iron and steel, injectors, shafting, etc. Example:[1] varies from 0.67 (Bldg's.) to 4.4. (Excav) percent of labor cost.

(4) **General Expense.**—Accessory materials, small repair items, etc., such as bolts, dynamite, waterproof garments, locks, nails, sand paper, lantern glasses, etc. Example:[1] varies from 2.1 to 17.3 percent of labor cost.

(5) **Electricity.**—For light and power.

(Bo.) Bonds and Insurance Costs.—(A direct charge against each job.)
Contract Bonds, Maintenance Bonds, etc., Liability Insurance, comprising Employer's Liability, Public Liability and Workmen's Collective Insurance.

(Int.) Interest on money borrowed to prosecute the contract while waiting for payments. In case no payments are made until work is completed, add full interest plus a bonus or fee for money borrowed at high interest on a speculative risk[1].

(Mi.) Miscellaneous Costs.—(Includes all costs directly chargeable to the job which cannot be classified under any of the above headings. Estimate, or, if records are available, express as a percentage of the labor cost.)
Transportation of Plant and Labor.
Transportation of Materials.
Photographs, Postage, Tel. and Tel.
Right-of-way through farms.
Lease of site, rent of quarry, etc.
Licenses and Taxes.
Riot protection and detective work.
Sanitation.

(Con.) Contingencies.—A percentage of the Direct Labor Cost to cover possible inefficiency of laborers, strikes, rise in rates of wages, etc.

(Com.) Commissary Cost. (Estimate direct, or, if records are available, express as percentage of labor cost. Example:[1] 3.5 percent for permanent camps, 7 percent for movable camps (averages).

(Ov.) Overhead Costs.—(Includes all expenses of the general office or of running the business that cannot be charged to any one job. Expressed as a percentage of direct labor cost, either estimated, or based on previous experience.)
Salary Costs of manager, ch. engineer, estimator, bookkeeper, stenographer, office boy, etc.
Office Supplies.
Misc. Office Expenses, such as rent, tel. and tel., postage, furniture depr., insurance, etc.

[1] See Ref DeW. V. M., p. 276.

General Misc. Expenses, such as advertising, legal services, charity, etc.
Salaries of superintendents, foremen, etc., when on idle list.

(Pr.) **Profit.**

The percentage of profit on labor and materials is preferably estimated separately; or, as outlined above, a separate percentage may be given to *each* of the items of Direct Cost, and to the total Indirect, and the quantities summarized. As a check, for purposes of mental comparison, ascertain what percentage the total profit bears to the total Dir. and Ind. (estimated) cost.

Outline of a Cost-Keeping and Estimating System for a Construction Company

This subject will be considered in its details under the following headings:

(1) Time Sheets and Weekly Cost Reports.
(2) Weekly Summaries and Progress Charts.
(3) Final Job Summaries.
(4) Segregated Cost Data.
(5) Estimating System.

The forms and methods presented are ones which were considered as more particularly applicable to the needs of a small engineering-contracting company operating in a city of 80,000 inhabitants, and in the surrounding territory. The company in question was managed by a trained engineer and by a foreman of first-class abilities working in conjunction, but the matter of cost keeping had not at first received proper attention, and financial difficulties were encountered, the true cause of which was hard to trace. A study of the subject (cost keeping and estimating), principally in the files of "Engineering-Contracting," in Gillette & Dana's "Cost Keeping and Management Engineering," and in a series of articles by Mr. DeWitt V. Moore in "Municipal Engineering" for 1911, led to the selection of one or two favored systems for each of the various operations of Field Records, Cost and Progress Records, Final Analysis, Estimating, etc., and the forms and methods relating to the same are reproduced below. The principal idea of their presentation in this instance is to illustrate the system or method on which the installation was based; and they exemplify the result of a careful study of the subject from the point of view of the small contracting company, and are believed to be in line with the best practice of the art. More particularly, the articles by Mr. Moore above referred to, were drawn upon for ideas and forms; they being, in the opinion of the author, the most scientific, practical and complete exposition of the subject that has yet appeared in print.[1]

[1] The author is informed that Mr Moore now has in preparation a book dealing with the subject of "Contracting Practice" in which he further expounds the system developed in the articles in "Municipal Engineering" above referred to, and increases their scope, using, as a basis, instructions issued to his own organization.

Time Sheets and Weekly Cost Reports

These consist of reports made out by the timekeeper, foreman or engineer showing the amount and distribution of labor costs; the amount of concrete, timbering, etc., installed; the carloads, etc., of materials received; and any other data which may influence the cost or progress of the work.

On small jobs, employing only a few men, such records can be advantageously **submitted once a week;** but on larger jobs, a daily rendering is preferable.

The multiplicity of methods and forms for daily reports is such that no attempt will be made in this volume to discuss or reproduce more than one style; the subject is quite thoroughly illustrated in the works referred to in the preceeding article. In general they may be classified as (1) those made specially for every operation but following a general scheme, and, (2) blank forms constructed so as to be applicable to practically every kind of construction work. The former allow the cost keeping to be carried to its furthest analysis; while the latter are more suitable for other (usually the smaller) concerns who are content with less detailed results.

A time sheet illustrating the latter system is shown (front and back) in Figs. 90 and 91. In its original form it seems to have **first appeared in "Engineering-Contracting"** for Jan. 13, 1909, illustrating the methods of the Moore-Mansfield Construction Co., and associated companies; but it also appears, with amplified description, in an article by DeWitt V. Moore in "Municipal Engineering," 1911 (see ref. p. 276) and varieties of the same scheme have also appeared, so that **its general utility has been amply tried** and demonstrated, and it would seem to be one of the best types of Time Sheets presented for the needs of the construction contractor.

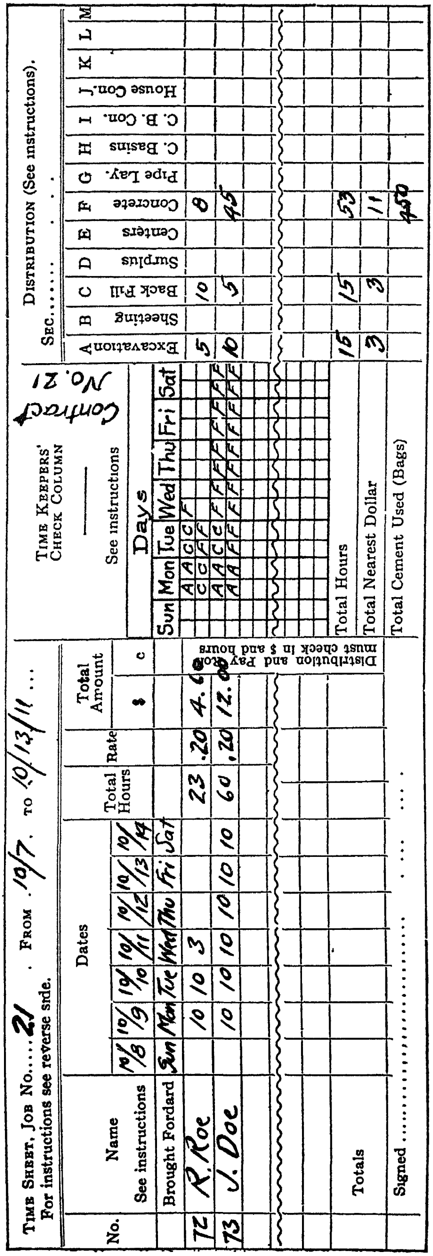
"This form of timekeeping[1] would be of value because of **the system of uniformity alone,** even if no regard were given to the other features mentioned, although the above companies using this report are satisfied that they are securing more valuable data by this form than they would have ever been able to do by previous forms used. The value of the uniform time sheet lies in the education of the timekeeper, resulting in a more efficient working force. Under the old system with individual sheets, prepared especially for each job, the form of the time sheets were many and various, and, for this very reason, timekeepers presumed to incorporate their own ideas and make changes and innovations, resulting in a bunch of data that required hours and generally the personal attendance of the timekeepers to work out and reduce to any satisfactory understanding."

Labor, Time and Cost Records

The instructions for using the time sheet shown in Figs. 90 and 91,

[1] Eng.-Contr., Jan. 13, 1909.

are given on the sheets themselves, but for greater legibility are reproduced below.



TIME SHEET, JOB No.....21 . FROM 10/7. TO 10/13/11 ...
For instructions see reverse side.

No.	Name (See instructions)	Sun 10/8	Mon 10/9	Tue 10/10	Wed 10/11	Thu 10/12	Fri 10/13	Sat 10/14	Total Hours	Rate	Total Amount $	c
	Brought Fordard											
72	R. Roe		10	10	3				23	.20	4.	60
73	J. Doe		10	10	10	10	10	10	60	.20	12.	00
	Totals											
	Signed											

Distribution and Pay Roll must check in $ and hours

TIME KEEPERS' CHECK COLUMN — See instructions — Contract No. 21 — Days: Sun, Mon, Tue, Wed, Thu, Fri, Sat — Total Hours — Total Nearest Dollar — Total Cement Used (Bags)

DISTRIBUTION (See instructions). SEC.......

	A Excavation	B Sheeting	C Back Fill	D Surplus	E Centers	F Concrete	G Pipe Lay.	H C. Basins	I C. B. Con.	J House Con.	K	L	M
	5		10			8							
	10		5			45							
Total Hours	15		15			53							
Total Nearest Dollar	3		3			11							
Total Cement Used (Bags)						450							

FIG. 90.—Front view of time sheet. (Actual size of sheet is 8 1/2 × 10 in.)

"It is intended that this sheet shall be used for all jobs, whether timekeeper makes report to pay-roll clerk daily, weekly, or monthly, and is to be used also for making summary reports. In using this time sheet side, always place date at head of column, and when marking out summary sheet place daily dates in the name column. In using the distribution side, the column marked "Timekeeper's check column" must have dates placed at the head corresponding to the time sheet side, and each column represents one day, the distribution being taken four times per day and marked inside of the four little squares, using distribution letter. However, for daily sheets, each vertical column represents 1 hour, and separation of time must be checked to the hour. Distribution columns will be headed by rubber stamp for each job and each man's time must be distributed under the proper columns and the totals reduced to dollars and shown at the foot of sheet, except that for summary sheets, total for each day will show opposite same. Timekeepers and engineers will cooperate to insure that summary sheets are correct as to time distribution and amount of work done. Daily time sheets must be turned in to the office at the close of each day: weekly time sheets each Thursday evening, and bi-monthly or monthly sheets will be separated and turned in at least once each week. No change of rate of pay will be allowed between pay-roll periods."

"No deviation from these instructions will be allowed on any job."

"It will be noted[1] that the distribution columns are headed by letters. No two

[1] See Ref, DeW V M., p 276.

Freight and Car Report

Car		Loading		Received		Unloaded	
Initial	Number	Kind	Amount	Place	Date	Place	Date
B & O	11461Z	Lumber	18M	#21	10/11	#21	10/13
B & O	32537	Cement	200 bbl	"	"	"	"

Expense

Name	Items	Amount	
John Smith	Carfare		65

Cement Used (Bags)

Dates	Where Used					
	Walls	Floors	Footing			
10/10-11			150			
10/12	100					
10/13		200				
Total	100	200	150			

Report of Work. Job No .. 21 .... From .. 10/7 .. To 10/13/11

Sec. ...... Contract Item No. 21	Previous Report			This Period			Total to Date		
	Pay Roll	Quant	Unit Cost	Pay Roll	Quant.	Unit Cost	Pay Roll	Quant.	Unit Cost
Excavation, cu. yds	1000	1000	1^{00}	200	100	2^{00}	1200	1100	1^{10}
Sheeting, lin. ft.									
Back Fill, cu yds									
Surplus, cu. yds.									
Centers, lin. ft.									
Concrete, cu. yds.	600	300	2^{00}	600	400	1^{50}	1200	700	1^{70}
Pipe Lay, lin. ft.									
C. Basins, No.									
C. B. Con, lin ft.									
House, lin. ft.									

Signed ______________________

INSTRUCTIONS.

It is intended that this sheet shall be used for all jobs, whether timekeeper makes report to pay-roll clerk daily, weekly, or monthly, and is to be used also for making summary reports. In using this time sheet side, always place date at head of column, and when marking out summary sheet place daily dates in the name column. In using the distribution side, the column marked "Timekeeper's check column" must have dates placed at the head corresponding to the time sheet side, and each column represents one day, the distribution being taken four times per day and marked inside of the four little squares, using distribution letter. However, for daily sheets, each vertical column represents one hour, and separation of time must be checked to the hour. Distribution columns will be headed by rubber stamp for each job and each man's time must be distributed under the proper columns and the totals reduced to dollars and shown at the foot of sheet, except that for summary sheets, total for each day will show opposite same. Timekeepers and engineers will co-operate to insure that summary sheets are correct as to time distribution and amount of work done. Daily time sheets must be turned in to the office at the close of each day, weekly time sheets each Thursday evening, and bi-monthly or monthly sheets will be separated and turned in at least once each week. No change of rate of pay will be allowed between pay-roll periods.

No deviation from these instructions will be allowed on any job.

Fig. 91.—Back view of time sheet.

jobs may have the same letters for the same kind of work, but for the particular job each letter stands for a classification of work and the cost distribution book is likewise headed, so that there can be no error.

"The actual size of this time sheet is 8 1/4 in. high by 10 in. wide and provides for 25 names and 13 distributions. In use the time sheet should be placed in a cover———which holds the sheet by the corners in the same manner as the ordinary desk pad. The covers can be placed in the side pocket of the coat, being 5 1/4 in. by 8 1/2 in.

"Plate X (not reproduced, Auth.) shows the front or timekeeping side of the time sheet arranged for daily reports. Plate XI (see Fig. 90, Auth.) shows the same form of time sheet as used for weekly reports. The top and bottom of these sheets are shown, the number of lines between being sufficient to fill the space between, ———."

Considering further the "Timekeeper's Check Column," we see from the example that Richard Roe worked on excavation (A) on Monday morning, and on filling (C) in the afternoon, continuing the latter work until noon of Tuesday when he was placed on concreting (F) at which he was kept until his discharge after 3 hours' work on Wednesday morning.

The use of the "Check Column" on making up the "Distributions" will be evident from the above example.

Material and Miscellaneous Records

The reverse side of the time sheet (Fig. 91) is also used to keep a "Car Report," "Expense" account, and a record of the amount of cement used; the manner of keeping these records is sufficiently indicated by the examples.

Summary Records

On the right hand side of the back of the Time Sheet (Fig. 91) is a form of giving a complete report of the job to date. The items of construction, etc., are printed in with the same **rubber stamps** as are used for the Distribution Heading (Fig. 90) and **in the same order.** "If the timekeeper[1] is unable or not competent to make a report of the amount of work accomplished, one of the supervising engineers cooperates with him to secure this information, so that the report may be a complete one."

Weekly Summaries and Progress Charts

The principal object in the compilation of weekly summaries "to date," and the equivalent progress charts, is to be able to form an opinion as to how the job in detail is progressing, both as to time and as to cost. By their means, it should be possible to detect, and to im-

[1] Eng.-Contr., Jan. 13, 1909.

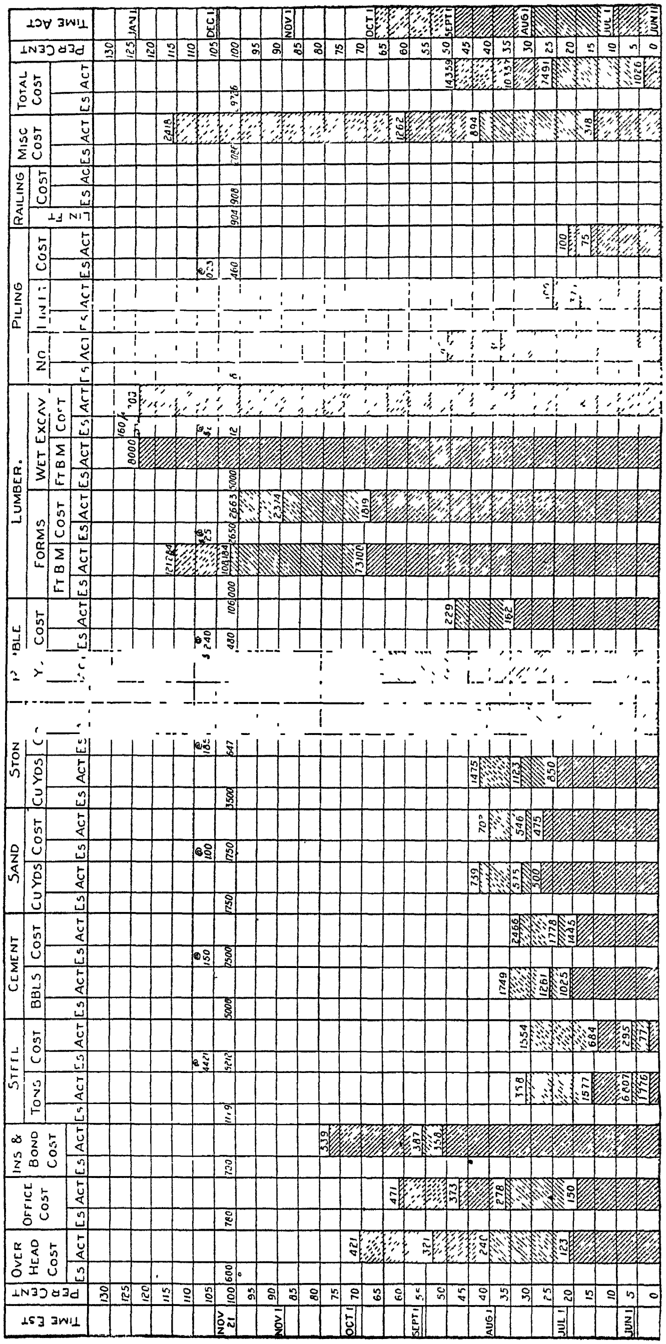


FIG. 92.—Chart showing expenditure for materials on construction cost keeping.

mediately apply a remedy for, any lagging behind schedule of any section of the work, or any undue costs that may be piling up.

The reverse side of the Time Sheet as illustrated in Fig. 91 **constitutes,** if the report is made out weekly, **a summary to date of the cost of the job.** It will serve also, to illustrate the general style of such periodic reports. By a comparison of these costs with the estimate, it might be possible, in some cases, to form a general idea as to how the job was "going," but **a better method of demonstration is by the "progress chart"** made out on the "percentage system." Illustrations of such charts and a description of their use are given in Chapter X, p. 404, Figs. 162 and 163. The first, Fig. 162, is called the **Labor Chart** and contains only the items shown on the pay-roll sheets, but it shows, also, the amount of work performed, excavation made, concrete poured, etc., in total amount and also percentage to date. The second, Fig. 163, gives a **summary of Labor, Material and Plant** cost and needs no further comment. The **Material Expenditure** chart is shown above, Fig. 92. This really shows all other items of expense not shown on the Labor Chart, except that of plant and equipment, the three items not material being General Overhead Expense, Office Expense, and Cost of Insurance and Bond. All other items are material items and are taken directly from the books for that job. All hauling, loading unloading, etc., of material is charged to material directly and not as a labor item. The unit costs of the different items on the Material Chart gives the costs placed on the job ready to be incorporated into the completed structure.

One of the most important items in the Material Chart is that headed **"Miscellaneous Cost;"** this being the account that has undiscernably embarrassed many a contracting concern which was apparently carrying on its jobs well within the estimated prices. Small items of material and little jobs not expected creep in on the work, and small invoices keep piling up; and when, some day, accounts are balanced, the company finds itself financially embarrassed, and cannot satisfactorily account for the conditions: the progress cost charts would tell the tale at a glance, or to be more correct, would probably have obviated the condition by pointing to the danger in time.

Final Job Summaries

Secondary to showing the amount of profit or loss on the job as a whole, the importance of the final job summary consists in its indication of profit or loss on the individual items of construction as compared with the estimate.

One striking advantage in **progress charts** of the type illustrated in Figs. 92, 162 and 163, is that, on the final entry being made, they stand as **completed job summaries,** both as to details and as to totals. Filed away with a construction progress drawing (Fig. 160) and photographs

of the work, they form a very complete record for use in estimating on other jobs.

Another method of recording final results is by the use of a "**Master Card,**" an example of which, as used by the Aberthaw Construction Co.[1]

Job No 747
Date May 24, 1906. Mill, Tappan Bros , Attleboro, Mass

	Proposal	Actual cost	Per cu. ft	Profit	Loss	Per cent
Total	$35,164 55	$31,330 48	... ...	$3,834 07	$. ..	11
Excavate	790 00	823 18	0 021	. .	33.18	
Footings and Fr	1,738.00	1,033.57	0 137	704.43	.. ..	.
			Per sq ft			
Exterior walls	1,955 00	2,162 02	0 190	. .. .	207.02	
Wall and Fr centres.	1,520 00	3,630 08	0 125	.	2,110 08	
Floors, 6⅝ in. thick	8,883 00	6,542 16	0 339	2,338 84	. .	.
Roof 5¼ in thick	2,869.00	1,713 51	0 237	1,155 49	. .	
			Per l. ft			
Columns, 20 × 20 in.	832.00	676.65	1 470	155 35	. . . . .	
Stairs....	883.00	910 35	0 912	. . . .	27.35	
			Per sq ft			
Tool surface	469 00	636 53	0 056	.....	167.53	
Ornaments and cornice	348 00	164 33	... ..	183 67	....	
Ventilators on roof	44.00	35 64	.	8 36	. . . .	. .
			Each.			
Set windows and door frames	852.00	729 99	2 19	122 01	.	.
			Per sq ft.			
Interior partitions	1,770 25	1,656 35	0 189	133.90	.. . ..	.
Bolts and iron work	253.00	257 06	. .. ...	.. .	4 06	
Stair railing and grill	387.00	654 00	... . ..	..	267 00	
			Per M			
Screens and setting	1,086 00	835 12	52 17	250 88	.. ..	.
2 in. Spr. plank and laying	2,839 00	1,431 69	33.30	1,407 31	...	.
7-8 in. Maple plank and laying	1,738 00	1,788 88	89 44	. ..	50 88	.
Motor shaft... ..	379 50	533 19	98.89	..... .	153.69	
Motor shaft found	98.00	70 07	. .	27 93	153 69	.
Roofing and conductors .	1,255.00	1,026 06	.	288.94	. .	
			Per sq. ft			
Paving	1,009 00	647 54	0 094	361 46	. . .	
Retaining wall:						
Centres, per sq. ft	....	. . . ...	0 211	. . . . .	. .	. . .
Concrete, per cu. ft.	429 00	316 90	0 175	112 10	.	..
Painting	400 00	375 00	.	25.00	......	.
Steel footings and walls.	300 00	218 91	.. . . .	81 09	. . .	
Plant frt , etc	1,860 00	2,271.73	. .		411 73	..
Bond	100 00	120 00	. . .	. . ....	20.00	. .
Extras	77 80	67 97	.	. ..	. ....	.
				9 83		

FIG. 93.—Master card, giving complete cost of a job.

is given in Fig. 93. On the side shown, the actual costs are recorded on the same arrangement as was used for the proposal or estimate, and results compared; also, actual costs are reduced to proper units for use in future estimates. On the back of the card, the principal items, such

[1] "Eng.-Contr.," Jan 13, 1909, p. 28.

as columns, floors, etc., are worked out more in detail, costs being segregated according to classes of labor, materials used, etc.

Segregated Cost Data

The data of the "Final Job Summary" described above, while it may be sufficiently complete, is not, as a rule, quickly "get-at-able" by anybody, and its arrangement, therefore, violates two of the fundamental laws of indexing. For example, cost data is required on the building of concrete stairways; such stairways may have occurred as details on a large number of previous jobs, but dependence must be placed on someone's memory if the master cards are to be located. The remedies are: either (1) to **construct a card-index** arranged alphabetically or topically, listing items and **referring to the master cards** on which they may be found; *or*, (2) **to enter the detail data on loose leaves** and arrange in a binder according to some convenient classification. Suggestions as to systems of indexing and the appliances of card indexes are given in Chapter XI, p. 411 *et seq.*, and where also may be found remarks on loose-leaf methods.

A complete description of a method of installing a detail cost-data system is given in this chapter on pp. 228 to 230. **The system** illustrated applies more particularly to machine costs, but, with slight modifications, **is perfectly applicable to construction data.** The **warnings** given as to the necessity of competent technical supervision of this work apply with even greater emphasis to construction data, for there are, today, many experienced engineers who doubt the efficacy of such cost data, basing their objections principally upon the difficulty of preserving and presenting such data in such a way as to be available for future guidance. In this connection the author would emphasize once more the great importance of **photographs** in cost-data work, and would recommend that they be filed with the cost data, or at least be mounted and indexed in such a way as to be immediately available. To this end, a space on the heading sheet referring to the photograph file and number would be advantageous.

A System of Construction Estimating

The following exposition is condensed from articles on "Contracting Practice" in "Municipal Engineering" for July and August, 1911, by DeWitt V. Moore.[1]

Relation of Estimating to Contracting Procedure

Contracting Procedure can best be considered under the following divisions:

[1] See footnote on p 276.

(a) Estimating the job;
(b) Construction of the job;
(c) A final analysis and recording of costs;
all these operations being conducted as parts of one general scheme, and being, therefore, mutually helpful and comparable. In other words, it is not allowable, under Mr. Moore's system, for the Estimating Department to get out their results by methods convenient to themselves only, nor for the Construction Department to keep records for ease in making up the pay-roll alone; but both must work on a system which will be suitable, not only for their own performances, but also for a comparison and analysis of records which will be of the greatest use to the present and future operations of the company.

Construction Estimating will be considered under the following heads:

(1) Outline of Work.
(2) Scheme of Operation.
(3) Itemized Quantity Estimate.
(4) Itemized Cost Estimate.

Outline of Work

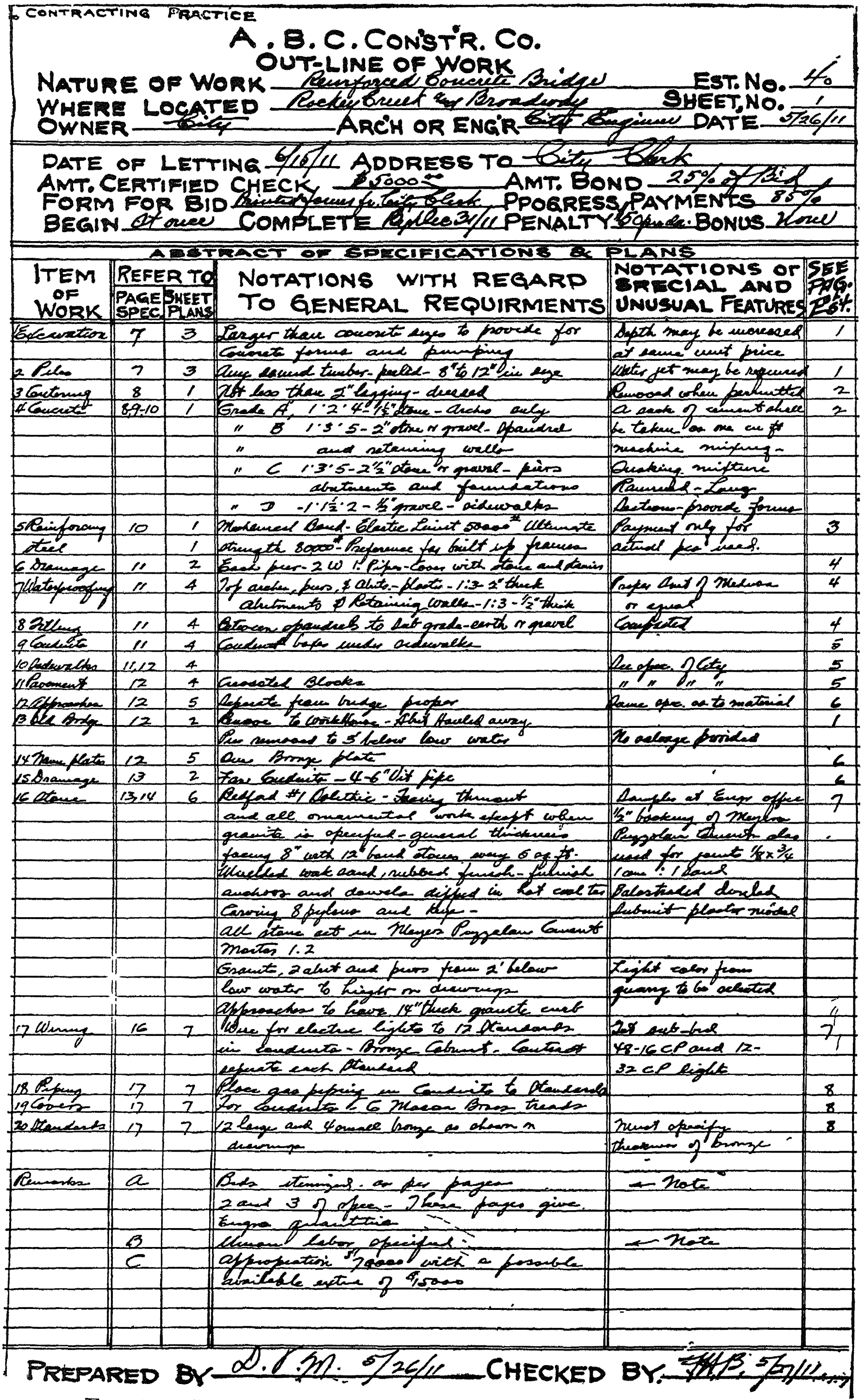
On a standard form such as is shown in Fig. 94 is recorded all the general and special features of the job as given in the specifications and plans.

The advantages of this method of outlining and recording proposed work are:

(1) A systematic, intimate acquaintance with the subject-matter is gained by the persons making and checking the outline.
(2) The scope of the work is presented in the best possible condensed form for pricing. In the example given, 18 pages of specifications were epitomized on one such "Outline of Work" sheet.
(3) A differentiation is made between usual and unusual clauses in the specifications; and the latter are presented to the eye in a striking manner, so that due allowance for them in the estimate is made almost automatically.
(4) Omissions are guarded against.
(5) The abstracts are of permanent value as part of the estimate files.

Scheme of Operation

On each and every estimate a scheme of operation for the job is planned and recorded with care and thoroughness, including a consideration of, (1) how the job can be handled, (2) what equipment is necessary, (3) how it is to be placed, and (4) what organization is nec-



CONTRACTING PRACTICE

A. B. C. CONS'T'R. CO.

OUT-LINE OF WORK

NATURE OF WORK Reinforced Concrete Bridge EST. NO. 40
WHERE LOCATED Rocky Creek & Broadway SHEET, NO. 1
OWNER City ARCH OR ENG'R City Engineer DATE 5/26/11

DATE OF LETTING 6/16/11 ADDRESS TO City Clerk
AMT. CERTIFIED CHECK $5000.00 AMT. BOND 25% of Bid
FORM FOR BID Printed forms fr. City Clerk PROGRESS PAYMENTS 85%
BEGIN At once COMPLETE By Dec 31/11 PENALTY $50 per day BONUS None

ABSTRACT OF SPECIFICATIONS & PLANS

ITEM OF WORK	REFER TO PAGE SPEC.	REFER TO SHEET PLANS	NOTATIONS WITH REGARD TO GENERAL REQUIRMENTS	NOTATIONS OF SPECIAL AND UNUSUAL FEATURES	SEE PAG. EST.
1 Excavation	7	3	Larger than concrete sizes to provide for concrete forms and pumping	Depth may be increased at same unit price	1
2 Piles	7	3	Any sound timber - peeled - 8" to 12" in size	Water jet may be required	1
3 Centering	8	1	Not less than 2" lagging - dressed	Removed when permitted	2
4 Concrete	8-9-10	1	Grade A, 1:2:4-1½" stone - Arches only	A sack of cement shall	2
			" B 1:3:5-2" stone or gravel - Spandrel	be taken as one cu ft	
			" and retaining walls	machine mixing -	
			" C 1:3:5-2½" stone or gravel - piers	Quaking mixture	
			abutments and foundations	Rammed - Long	
			" D -1:1½:2-½" gravel - sidewalks	Section - provide forms	
5 Reinforcing steel	10	1	Mechanical Bond - Elastic Limit 50000# Ultimate strength 80000# - Preference for built up frames	Payment only for actual pcs used.	3
6 Drainage	11	2	Each pier - 2 W. I. Pipes - Cover with stone and screen		4
7 Waterproofing	11	4	Top arches, piers, & Abuts. - plaster - 1:3 - ½" thick abutments & Retaining walls - 1:3 - ½" thick	Proper Amt of Medusa or equal	4
8 Filling	11	4	Between spandrels to sub grade - earth or gravel	Compacted	4
9 Conduits	11	4	Conduit boxes under sidewalks		5
10 Sidewalks	11, 12	4		See spec. of City	5
11 Pavement	12	4	Creosoted Blocks	" " " "	5
12 Approaches	12	5	Separate from bridge proper	Same spec. as to material	6
13 Old Bridge	12	2	Remove to Workhouse - Abut Hauled away		1
			Piers removed to 3' below low water	No salvage provided	
14 Name plates	12	5	One Bronze plate		6
15 Drainage	13	2	Four Conduits - 4-6" Vit pipe		6
16 Stone	13, 14	6	Bedford #1 Oolitic - Facing thruout and all ornamental work except when granite is specified - general thickness facing 8" with 12" bond stones every 6 sq ft. Washed rock sand, rubbed finish - furnish anchors and dowels dipped in hot coal tar. Carving 8 pylons and keys - All stone set in Meyers Pozzolan Cement Mortar 1:2	Samples at Engrs office. ½" backing of Meyers Pozzolan Cement also used for joints 1/8 x 3/4 1 cem. : 1 sand. Balustrade dowled. Submit plaster model	7
			Granite, 2 abut and piers from 2' below low water to high on drawings	Light color from quarry to be selected	
			Approaches to have 14" thick granite curb		
17 Wiring	16	7	Wire for electric lights to 12 Standards in conduits - Bronze Cabinet - Contact separate each Standard	2# sub-bid 48-16 CP and 12-32 CP light	7
18 Piping	17	7	Place gas piping in Conduits to Standards		8
19 Covers	17	7	For Conduits & 6 Mason Brass treads		8
20 Standards	17	7	12 large and 4 small bronze as shown on drawings	Must specify thickness of Bronze	8
Remarks	a		Bids itemized - as per pages 2 and 3 of spec. - These pages give Engrs quantities	← Note	
	B		Union labor specified	← Note	
	C		Appropriation $70000 with a possible available extra of $15000		

PREPARED BY D. F. M. 5/26/11 CHECKED BY H. B. 5/27/11

FIG. 94.—Summary of work required for reinforced concrete bridge.

essary—to execute the work at the least cost. These important matters are *not* left for consideration after the job is secured on a "guess bid."

The basis of the scheme of operation as used by Mr. Moore consists in the production of a combined small-scale diagram of the entire job (such as might be used for a progress chart) and a schedule of quantities, etc., for each main division of the work. Space does not permit the reproduction of the illustration[1] (for a sewer job), but it comprises on one sheet a diagrammatic plan and profile of the job, and a schedule of quantities of excavations, concrete, etc., for different sections of the work.

This plan is prepared in such a manner that it can be preserved; and, in the event that the contract is secured, it is completed and traced, and forms a basis for the work. If possible, it is made on the same scale as the general plans of the work, it being often possible to trace from them and to then add the necessary notations and symbols.

The advantages of such graphical preliminary investigations are:

(1) A "bird's eye view" of the entire job is afforded, with which the contractor can go into the field, view the site, and be properly prepared to make an intelligent estimate from the working drawings.

(2) A condensed profile will assist the preparation of an estimate far in excess of the value of the time to prepare the same.

(3) Different conditions and probable difficulties of construction are clearly indicated.

(4) There will be produced a plan of operation and a feeling of certainty and promptness in the beginning of the work which will go a long way toward satisfying both parties.

(5) Changes and new ideas of operation can be studied with less chances of confusion.

Itemized Quantity Estimate

All quantities are taken off and recorded on a standard form such as is shown in Fig. 95, this form being applicable to all kinds of construction work. It will be noted that it is of the same form as the "Outline of Work" blank, and is intended for filing with it.

The advantages in the use of such a standard form are:

(1) The quantities of the estimate may be checked—an almost impossible performance when the estimator follows his own peculiar ideas.

(2) Systematic methods of taking off quantities and grouping according to unit values are almost forced upon the estimator.

(3) A complete record is kept of the quantities called for on the original

[1] Also shown in Gillette and Dana's "Cost Keeping and Management Engineering," Myron C. Clark, Pub Co.

CONTRACTING PRACTICE PLATE VI

A-B-C CONST'R CO.

ITEMIZED QUANTITY ESTIMATE

NATURE OF WORK Illustration of use of this form

WHERE LOCATED

OWNER ARCH OR ENGR.

EST NO	41
SHEET NO	1
DATE	9/10/11
ESTIMATED BY	F.B.
EXTENDED BY	W.V.L.
RECAPITULATED BY	F.B.
CHECKED BY	O.V.M.
REVISION SEE SHEET	

GROUP ITEMS WITH BRACKETS		ITEM OF WORK	LOCATION	SHEET PLANS	PAGE SPEC.	DIMENSIONS: LENGTH	WIDTH OR HEIGHT	THICKNESS OR DEPTH	NO OF PIECES	QUANTITIES BY UNITS & TOTALS (WRITE IN PROPER HEADING FOR EACH ITEM OF WORK): UNIT	TOTAL	UNIT	TOTAL	UNIT	TOTAL	UNIT	TOTAL	UNIT	TOTAL
Excavation	1	Excav									Bldg Excav		Sewer Excav		Bldg Sheeting		Sewer Sheeting		Gravel
	2		Main Bldg	1	4	100	54	10		27	2000			3"	9720			½	1000
	3		Alley Wing	1	4	54	27	12		27	648			3"	4860			½	324
	4		Sewers	2	5	400	3	15				27	666			2L	30000		—
	5	Total									2648		666		14100		30000		1324
R. Conc.	6	Concrete									Cement		Forms		Wt. Proof				
	7	1:3:6	Main Bldg	2	6	308	12	Av. 1½		27	205	3"	11088		Medium				
	8		Wing "	2	6	135	14	" 1½		27	105	3"	5670						
	9		Base Floor	2	7	127	54	4"		27	85			8"	680#	1/20	428 cu'		
	10	Total									395		16758		680#		428		
R. Conc.	11	Concrete									Cement		Forms		Centers		Steel		Gravel Roof
	12	1:2:4	Columns	3	8/9	10	1½	1½	24	27	20	21	5040			6	1440		
	13		Girders	3	9	27	1¼	2½	16	27	50	14	6048			10	4320		
	14		Roof	3	9/10	127	54	4"		27	85			4	27432	10	7338		68.6
	15		etc etc																
	16	Total									155		11085		27432		13098		68.6
	17																		
	18														Face		Fire		
Brick	19	Brick	St Front	4	14/15	54	15	13"		15	12150	5/6	9120	7	5670				
	20		Side walls	5/6	"	173	15	13		22	57090	"	42810						
	21		Alley Wall	7	"	108	10	13"		22	23760	"	17820						
	22		Wing Walls	5	"	81	10	8"		15	12150	"	9120						
	23		Partitions	8	"	27	8	8"		15	3240		2430						
	24		Stack	8	16	40	3' Sq	8"4"		15	7200		5400			7	3360		
	25		etc																
	26		etc																
	27	Total																	
	28																		
	29																		
Str. Steel	30	Struct								#	12" I		10" I		6" I		6x4 L		C.I. Col.
	31	Steel	1st floor	6	15	14			32	40	17920								
	32		2nd "	6	15	14			32			32	14336						
	33		1st floor	"	"	10			64					18	11520				
	34		2nd "	"	"	10			64					13	8320				
	35		Roof	"	"	14			32			32	14336						
	36		"	"	"	10			32					13	4160				
	37		1st floor	"	"	14			64							12.3	11021		
	38		2nd "	"	"	"			"							"	11021		
	39		1st "	6	16	10	6"	7/8	24									44	10560
	40		2nd "	6	16	10	6"	½	24									27	6480
	41		etc etc																
	42	Total																	
Reinf. Steel	43																		
	44	Reinforcing									¾		⅝		½		¼		¼ x ½
	45	Steel	Columns 1st	3	8/9	12	¾		4x24	13	1728								
	46		" Hoops	"		50			24									3#	400
	47		Bracing	3	9	27	4-¾ 4-⅝		4x16 4x20	15	2592	10	1728						
	48		Floors	3	10	20		.06"	860					2/3	11466				
	49		Roof	"	"	20		.06"	860							167	2872		
	50		etc																
	51		etc																
	52	Total																	
Timber	53	Timber									6x12		4x8		3"		1" T&G		12x12
	54		Cols 1st	3	8	10			24									12	2880
	55		1st F Gir	"	"	14			32	6	2688								
	56		1st F Beams	"	"	10			64			27	1728						
	57		1st floor			100	54							[illegible]	10440	[illegible]	20350		
	58		etc etc																
	59	Total																	

FIG. 95—Itemized quantity estimate: construction estimating.

DATA:-
Building 53 × 100
2 Sup floors & roof
Gen. Sk-Long Span Tile Constr.
Sq ft ___ per sq ft
Cu ft. ___ per cu ft.

A-B-C CONST'R CO.

ITEMIZED COST ESTIMATE

Smith Mfg. Co. — FOR WHOM
Metropolis — WHERE LOCATED
General Contract — WORK INCLUDED IN EST.
R-Concrete Bldg. — NATURE OF WORK

ESTIMATE No. 25
SHEET No 1
DATE 7-9-11
DESIGNED BY F.W.G.
QUANTITIES BY W.L.
EST PRICED BY D.T.W.

	1	2		3	4	5		6		7	8	9	10
	PRINCIPAL ITEM	QUANTITY AMT FROM ITEMIZED QUAN EST	UNIT	UNIT ITEMS COMPOSING PRINCIPAL ITEM: ITEM	QUOTATIONS ON MATERIAL	QUAN	PRICE	RESULTING UNIT PRICES PRINCIPAL ITEM: MAT	LAB	TOTAL COST OF MATERIAL COL #5 × #2	TOTAL COST OF LABOR COL #5 × #2	TOTAL COST MAT & LABOR	REMARKS
1	Excavation	510	Yds	Labor		510	125		.60		306		Dump 1 mile
2													
3	Filling	1000	Yds	Cinders	Per Car of	25 yds	5.00	20		200			Belt R.R.
4				Labor					.60		600		
5	Forms	114	M	Labor					27.00		3078		Union Lab.
6	Centers	120	M	Labor					17.00		2040		" "
7	Total F&C	234	M	Lumber		Use 1½	25	12.50		2925			Salvage consid.
8	Concrete	1650	Yds	Gravel	On Dock 65¢	9/10	1.00	90		1485			B.R.S.&G.Co
9	(1 2:4)			Sand	" " "	45/100	1.00	.45		743			" "
10				Cement	A P C Co	14/10	1.10	1.55		2557			
11				Water	Water Co.			.10		165			
12				Labor					1.75		2888		
13	S.P. Tile 6"	9500	Sq ft	Tile	B C Co.	F o b	.05	.05		475			
14	10"	18900	"	Tile	B C Co.	F o b	.07	.07		1323			
15	Total	28400		Labor		"			.01½		426		
16	Reinforcement	3¼	Tons	¼" Sqs.	S T Co.	F o b		45.00		146			
17		4/10	"	⅜" "	S T Co	F o b		43.00		17			
18		3/10	"	½" "	S T Co.	F o b		40.00		12			
19		3 6/10	"	⅝ "	S T Co	F o b.		39.00		140			Average
20		5	"	¾ "	S.T Co.	F o b		38.00		190			2 9/10 per #
21		48	"	½ & ¾	F.B Co	F o b		63.00		3024			Fabricated
22		20	"	1"	F B Co	F o b		58.00		1160			" "
23	Total	80 55/100	"	Labor		Ave			10.00		805		
24	Exp. Metal	2000	Sq ft		S.T Co	F o b		.04¢		80			
25	Total			M.&L.						14642	10143		
26	Gen Chg.			All Items					20%		2028		
27	Total			Cost								26813	
28	Profit					15%						4022	
29	Bid			Lump	Sum							$30835	
30													
31													
32	FOR Unit Price Bid on Concrete see Estimate below :-												
33													
34	Concrete	1650	Yds	Gravel		9/10	1.00	.90		1485			Unit Price
35	1650 yds.	1650	"	Sand		45/100	1.00	.45		743			wanted on
36		1650	"	Cement	A P C Co	14/10	1.10	1.55		2557			Concrete as
37		1650	"	Water				.10		165			additional
38		114	M	Forms	use 1½ times	69' B M	12.50	.86		1419			stories may
39		120	M.	Centers	" " "	73' B M.	12.50	91		1502			be added of
40		9500	Sq ft	Tile 6"	f o b	5¾ sq ft	.05	29		475			same type
41		18900	Sq ft	Tile 10"	f o b	11½ sq ft	.07	.80		1323			
42		80 55/100	Tons	Reinforcement		97 6/10	2 9/10	2.83		4689			See Itemization
43				Labor		Con			1.75		2888		
44		114	M	Labor		Forms	27.00		1.86		3078		
45		120	M	Labor		Centers	17.00		1.24		2040		
46		28400	Sq ft	Labor		Tile	.01½		.26		426		
47		80 55/100	Tons	Labor		Reinf	10.00		.49		805		
48	Total			M.&L.				8.69	5.60	14358	9237		
49	Gen Chg			All Items		20%			1.12		1847		
50	Total			Cost				15.	41			25442	
51	Profit					15%		2.	31			3816	
52	Bid			Per. Cu. Yd Concrete				$17.	72			29268	
53													
54													
55													
56													
57													
58	See sheets 2, 3, 4 and 5												
59													

FIG. 96.—Itemized cost estimate; construction estimating.

DATA:-	Cost per sq. ft. per Cu. ft.	
Excav. etc	—	—
R. Con etc	—	—
Mill Work etc	—	—
Painting etc	—	—
etc etc.	—	—
1	2	

A-B-C CONST'R CO.

Smith Mfg. Co. — FOR WHOM

Metropolis — WHERE LOCATED;

General Contract — WORK INCLUDED IN EST

R. Concrete Bldg. — NATURE OF WORK

3 4 5 6

ESTIMATE No	25
SHEET No.	4
DATE	7-9-11
DESIGNED BY	F.H.B.
QUANTITIES BY	W.J.L.
EST PRICED BY	D.W.

7 8 9

	PRINCIPAL ITEM	A-B-C-Co's, EST QUANTITY AMT	UNIT	UNIT PRICE	TOTAL	NAME OF SUB BIDDERS	SUB BIDS	SELECTED SUB BIDS FOR EST OF COST	UNIT PRICE SUB BIDS	REMARKS
1	Cement	5750	sq. ft.	11¢	633	Block Mfg Co.	690	690	12¢	
2	Blocks.					John Smith	725		12 6/10¢	
3						Cement Block Co.	745		13¢	
4										
5	Cement	1150	lin. ft.	25	288	Block Mfg. Co.	345	345	30¢	
6	Sills					John Smith	360		31 3/10¢	
7						Cement Block Co.	375		32 6/10¢	
8										
9	Cement									
10	Coping	525	lin. ft.	25	131	Block Mfg Co.	258		49¢	
11						John Smith	240		45 3/4	
12						Cement Block Co.	225		43	
13						Use Co. Est.		131		
14										
15	Mill Work				2000	Metropolis Lum. Co.	2120			See
16						Jones & Brown.	1600			Detail
17						Doe-Roe Co.	1860	1860		Est.
18										
19	Wood Sub	70	M	40.00	2800	1. Metropolis Lum Co.	3500		50.00	Laid
20	Floor					2. Jones & Brown.	2450		35.00	Mat f.o.b
21						3 Doe-Roe Co.	3000		42.80	Laid but Chg. in Spec
22						Use average 1 & 3		3250		
23										
24	Maple									
25	Floor	50	M.	40.00	2000	1. Metropolis Lum Co.	2100		42.00	Laid
26						2 Jones & Brown.	1500		30.00	Mat. f.o.b.
27						3 Doe-Roe Co.	2000	2000	40.00	Laid
28										
29	Sheet				No. Est.	Sheet Metal Co.	600	600		
30	Metal					Cornice Works	675			
31										
32	Painting	2000	"	.50	1000	H. J. McMicheals	980			?
33	Glazing & Oil.					C. I. Dunlop	1020	1020		
34						Compton & Baker	1200			
35										
36	Fire Doors	20. 1000'	sq. ft.	1.00	1000	Fire Door Co.	923	923		Installed
37						X Hardware Co	923			
38										
39	Etc									
40										
41	Etc									
42										
43										
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	Carried forwarded to Sheet No. 5.						c6750 3			

FIG. 97.—Sub-contractors' bids; construction estimating.

plans—usually returned—with which later plans can be compared and changes caught.

(4) It is of great value when the time comes to submit a schedule of quantities and prices for the preparation of the monthly estimates.

Itemized Cost Estimate

The "Itemized Cost Estimate" and "Sub-Contractors' Bids" are recorded on forms uniform in size and arrangement with that of the "Itemized Quantity Estimate." Examples of each are given in Figs. 96 and 97. It will be noted that columns 1 and 2 are taken directly from the "Itemized Quantity Estimate" recapitulation of totals, which are now dissected to analyze the cost. The method of extending the estimate is well illustrated by the examples.

"Upon the face of this Estimate Sheet we have every detail calculation of the cost and why it is so. There is no guess work about such a system, for even if some items are uncertain of determination by the plans, such items stand by themselves and can be verified or mention made in the proposal that a certain amount has been estimated."

"Any questions by the owner or architect can be answered at once and definitely. Any eliminated items can be deducted without recalculations."

CHAPTER VII

SAMPLING, INSPECTING AND TESTING ENGINEERING MATERIAL

Introduction

This chapter has been written more particularly for the needs of the office engineer or draftsman who is at intervals called upon to do inspection work in a more or less extemporary manner. Such contingencies occur quite frequently in engineering offices, and it often happens that a man is sent out to the works or the plant with few or no directions concerning the functions that are expected of him. In such cases the best of men are apt to overlook important features which may be the cause of subsequent trouble; while inspection by men of no particular aptitude to the work might just as well be omitted altogether, unless they are supplied with detailed instructions as to what to do and how to do it. The endeavor has been made, therefore, to outline the work that should actually be performed by the inspector in collecting samples, examining machinery and witnessing tests on the more common articles of engineering construction.

Frequent reference is made to Byrne's "Inspector's Pocket Book" (John Wiley & Sons, N. Y.) and Carpenter's "Experimental Engineering" (also by John Wiley & Sons), which may be considered as indispensable books in every engineer's library, and an attempt has been made to coördinate the directions therein given with the special requirements of the chance inspector.

It is not the purpose of this chapter to discuss the **psychology of the inspector's work** (although this is, of course, a matter of profound importance), but the following remarks, extracted from an article by Mr. Edward Godfrey in the Proceedings of the Engineers Society of Western Pennsylvania, Vol. 25, No. 7, manifest so clearly and concisely the status of the inspector that they are recommended for perusal by the engineer or draftsman inexperienced in this class of work, before proceeding on an inspection assignment.

"The primary idea of an inspector is probably best expressed in the law term *caveat emptor*—let the buyer beware. He is eyes for the buyer. A purchaser of a bridge, an office building, or any other thing that requires expert knowledge to pass upon, if he is wise, will employ an expert to see that he is getting what he pays for. This phase of an inspector's office is well understood. To some minds, however, the inspector is merely a critic, a fault-finder. In the nature of things he

must be a fault-finder. Perfection is only reached by eliminating faults. If an inspector looked for good points only, or largely, his opinion or report would be misleading or dangerous. One fault may be serious enough to cause a wreck. Manufacturers are sometimes provoked at an inspector because of the fact that he emphasizes faults and appears to overlook the good points in a piece of construction. The lateral system of a bridge may be faultless up to the connection with the shoe, but if this is a bent plate which would straighten out under a small stress, the perfection of the remainder of the lateral system counts for very little. Of course perfection cannot be attained, but imperfections may appear small and yet be great enough to be serious faults.

"Generally, an inspector is employed and paid by the buyer, and this gives the buyer the right to look for services devoted to himself alone. Some contracts provide that the seller must pay for inspection, but of course this is added to the price the buyer must pay and the relation to the buyer is unchanged. As an employee of the buyer the inspector's chief duty is to see that the specifications are carried out.

"An inspector in common justice must look on matters from the seller's view point, and furthermore there are many reasons why a manufacturer should regard him as an aid to his business rather than a hindrance. An inspector can do much to aid the manufacturer and in doing so further the interests of his employer, the buyer, and the wise manufacturer will appreciate this. It raises the standard of work to have constant critical supervision exercised over it. It seldom costs more to do a thing right than to do it wrong, and an inspector whose presence is an incentive to the workmen to do the thing right, rather than to have to do it twice, is increasing the efficiency of the shop. So that even considering the character of the workmanship, a good inspector, properly treated, pays for the trouble he may sometimes make.

"Buyers sometimes have the idea that the employment of an inspector is sufficient assurance of receiving the best kind of work that can be made. They overlook the fact that a shop with certain equipment and a certain class of skilled laborers can only reach a degree of perfection commensurate with the plant and the skill."

SEC. I. COLLECTING SAMPLES OF RAW MATERIAL

General Remarks

The collecting of samples of raw material for analysis or test is a matter the importance of which is frequently underestimated. The laboratory work is conducted under standardized methods concerning which there can be little question of procedure or results; but the initial field work is often left to the variable judgment of a haphazard collector, and the sample submitted may be anything but a fair criterion of the condition of the material to be tested. Results based on unrepresentative samples may lead to great financial losses, and even to constructions of dangerous proportion, more especially in reinforced concrete work.

Considerable stress is sometimes laid on the necessity for judgment on the part of the sampler; but, while this quality will always

be of importance, it is possible, by means of carefully drawn up instructions judiciously followed, to ensure results in whose value satisfactory confidence may be placed, even when the collector is not an expert in this line of work. This fact has long been recognized in the industries using valuable ores, etc., and very complete instructions are issued to the force whose business it is to take samples from ore-heaps, cars, vessels, etc., so that payments may be adjusted and proportions calculated.

In this section, therefore, are given selected methods of sampling the principal raw materials with which the engineer has to deal, as an aid to the occasional collector and as suggestive of methods suitable for similar materials.

For very succinct but complete descriptions of the raw materials of construction, their properties, adulterants, etc., see Byrne's "Inspector's Pocket Book."[1]

Sampling Sand, Etc., by Method of Quartering

From "Concrete, Plain and Reinforced," by Taylor and Thompson, p. 281.

> "To obtain an average sample from a pile of sand, gravel or stone, the method of quartering is useful. Shovelfuls of the material are taken from various parts of the pile, mixed together and spread in a circle. The circle is quartered, as one would quarter a pie, one of the quarters is shoveled away from the rest, thoroughly mixed, spread and quartered as before. The operation is repeated until the quantity is reduced to that required for the sample."

For refinements of the above method, such as must be used in sampling ore, etc., see the following article:

Ore Sampling by Hand

The proper sampling of ore for analysis on which to base payments, is evidently a much more important operation than the sampling of such materials as coal, sand, etc. The reason for this lies not only in the greater value of the material sampled, but more particularly, because the richness of the fine particles of an ore usually exceeds that of the larger pieces; and also because, in some ores more than in others, the greater values occur in "pockets." Sampling by hand, therefore, to be reliable, must be done according to a rational system, under the direction of a conscientious superintendent.

The **collection of the sample** will involve two operations: (1) the obtaining of the first large sample from the mass, and (2) the division and reduction of this sample to a size suitable for the laboratory.

[1] John Wiley & Sons, N. Y.

For the first operation, the most satisfactory method, probably, consists in taking out a section at regular intervals from a uniform "stream" of the material. This is the method used in ore-sampling houses where the stream of ore is diverted at regular intervals, the diverted sample crushed, "streamed" and again diverted and crushed, again and again, until the final laboratory sample is obtained, the whole process being conducted automatically. If the material is delivered so that it can be piled in a ring (say about 12 ft. in diameter), shovelfuls can be taken at regular intervals and thrown to the centre for subsequent subdivision. If the material is presented in a more or less uniform conical pile, a diametral path of material may be cut by shoveling; or better, two such paths at right angles may be cut, the material being piled, and the operation repeated as required.

For the second operation (the reduction of the sample to laboratory proportions) there are three methods in ordinary use, all of which, however, are sometimes used in obtaining one sample. The first is the well-known method of quartering, the second is by means of the "split shovel" and the third is by the use of the "riffle." The last two devices, however, are more strictly laboratory operations and will not be described here.

The method of quartering consists in piling the material in a conical heap, flattening out the cone with shovels or a board, dividing into equal quadrants, discarding two opposite quadrants, and repeating the operation with the remainder. The operation would appear to be simple and exact; but as a matter of fact it can become, or can be made, very inexact. If more of the fine material falls to one side than the other, the sample will be erroneous; men can be trained to pile and quarter the material so as to produce results favorable to their employer; also in the flattening out of the cone it is easy to get the fine material worked over to one side, and all this under the eyes of interested parties. If other safeguards are not adopted, a simple and equable rule is to have the seller do the quartering and to let the buyer make the selection of the quarters. One device consists in the use of a sheet-iron "cross" set on end, the material to be deposited at the intersection so that the quarters are formed automatically.

It is important in all these operations that **the dust** from each division be properly distributed, the floor being swept after each partition, as the greatest values are often in the smallest particles.[1]

The amount of the sample to be taken at each stage (taking copper ore as an example) is largely a function of the size of the largest pieces. In general, the whole batch is first crushed to about 3 1/2-in. size. From 15 to 20 percent is cut out for the sample. This is crushed to

[1] The above observations are extracted from "The Cyanide Handbook" by Clennell, and from Peters' "Practice of Copper Smelting" (both by McGraw-Hill Book Co , N. Y.), each of whom acknowledge indebtedness to the researches of Brunton.

1 3/4 in. and 20 percent taken, this to 3/4 in. and 15 percent taken, this to 1/4 in. and 15 percent taken, or 720 lb. from an original lot of ore of 400 tons. This 720 lb. would go to the sampling room for laboratory subdivision and analysis.

The following table (by S. A. Reed, "Sch. Mines Quart.," 6, p. 351, 1885, here copied from "The Cyanide Handbook") gives the **size of the pieces** to which the sample should be crushed for a given reduction:

Table IX.—Sample-crushing Sizes

Sample reduced from	Diameter largest piece in inches			
	Class A	Class B	Class C	Class A = medium Class B = high grade Class C = very rich ore
100 to 10 tons	5.28	2.96	2.58	
10 to 1 ton	2.46	1.38	1.2	
2000 to 200 lb	1.14	0.6	0.56	
200 to 5 lb	0.3	0.18	0.16	
5 lb to 10 assay tons	0.034	0.02	0.018	

Sampling Pig Iron

The following rules for taking samples for analysis are extracted (with slight modification) from the Standard Specifications for Foundry Pig Iron of the Am. Soc. for Testing Materials. The Society recommends that foundry pig iron be bought by analysis, and their specifications are based on this advice.

Each car load, or its equivalent, shall be considered as a unit in sampling.

One pig of machine-cast, or one-half pig of sand cast iron, shall be taken to every 4 tons in the car, and shall be so chosen from different parts of the car as to represent as nearly as possible the average quality of the iron.

Drillings shall be taken so as to fairly represent the composition of the pig as cast.

An equal weight of the drillings from each pig shall be thoroughly mixed to make up the sample for analysis.

Sampling Coal for Analysis

The following method is extracted from the "Report of the Committee on Coal Analysis," Journal of the American Chemical Society, 1899, Vol. 21, pp. 1116–1132.

Sampling.—In making an analysis in the laboratory only a very small quantity of the fuel is actually tested, and it is of the utmost importance that the sampling and subsequent preparation of the fuel should be carried out in such a way that

the small quantity which is tested truly represents the average of the whole bulk. The method which is recommended in testing a consignment of coal is as follows:

Shovelfuls of coal are taken at regular intervals during the unloading of the truck. The coal thus taken is placed on a close floor and is broken till there are no pieces larger than about 75 mm. or 3 in. cube. It is then well mixed and divided roughly into four equal parts; opposite quarters are rejected and the remaining half of the coal is broken to a smaller size. This process is repeated until the sample is reduced to about 1 kilo (2.2 lb.) in weight and consists of pieces about 5 mm. (3/16 in.) cube. It is then sealed up in an air-tight jar and kept for analysis. To avoid alteration in the percentage of moisture in the coal these operations should be carried out as quickly as possible.

It is fast becoming the universal practice among buyers of coal in any considerable quantity, to purchase on the basis of heat units delivered. Consequent on calls for specifications for the method, the U. S. Dept. of the Interior, Bureau of Mines, has issued Bulletin No. 11 from which the following remarks and method of sampling coal for analysis are extracted.

Adjustment of Price to Weight.—Bituminous coal when exposed to the air gradually depreciates in heating value, owing to loss of volatile matter, but aside from this loss a car of coal should represent the same total number of heat units when it reaches its destination as when it started. If rain falls on the coal it will become heavier and a greater number of pounds will be delivered, but each pound will have a correspondingly lower heat value. On the other hand, if the weather is fair and the coal dries out on the way, it will weigh less and the heating value of each pound will be correspondingly higher. In other words, under specifications such as are used by the Government, neither the dealer nor the purchaser will gain or lose by change in the moisture content of the coal between the time it is weighed at the mine and the time it is weighed on delivery. The price per ton will be correspondingly lower if the coal is wet and higher if the coal is dry.

Weight of Sample.—The number of pounds to be taken as a fair sample of a given lot of coal varies according to the size, character, and condition of the coal and depends also upon the character and amount of the extraneous matter as well as on the size of the particles of both coal and impurities. It is therefore evident that the sampling should not be left to an inexperienced person, but should be done by one who is thoroughly familiar with the significance of the factors just stated and who has some intimate knowledge of the coal to be sampled.

Need of Experience and Caution.—Persons who have had no experience in taking samples are liable to select a sample better than the average run of the coal. Occasionally a lump of coal is broken and shipped to the laboratory in a cloth sack, which allows the moisture to dry out; moreover, the lump selected is usually free from layers of slate and impurities, and of course then represents the best coal in the lot rather than the average, and its analysis will show a higher value than the coal delivered. Especial care should be exercised to note the proportion of slate and other foreign substances, in order that such impurities may be included in the sample in the same proportion. Experience and good judgment on the part of the sampler are necessary to insure the collection of a representative sample;

and it is well to remember that as the larger lumps of coal roll down and collect near the bottom of a pile or load a sample taken entirely from near the floor would not fairly represent the whole.

Samples taken from railroad cars should not be limited to a few shovelfuls of coal procured from the top of the car, for the quality of the coal may not be the same throughout the car; indeed, it is sometimes found that the heavier pieces have gradually shifted in transit toward the bottom. Tests of samples taken at the bottom of a car have shown as much as 8 percent more ash than samples taken at the top. The moisture content also may vary from top to bottom, depending on the weather. The only way to get a fair sample is to take a number of shovelfuls of coal from different points in the car when the coal is unloaded, so as to procure a representative portion of the coal from top to bottom and from end to end.

Loss of Moisture in Samples.—In spite of every precaution taken to prevent loss of moisture during the collection, preparation, and analyses of samples, it is certain that loss of moisture may occur, whereby the heat value of the coal as shown by analysis of the sample is greater than that of the coal from which the sample was taken. It is important to the purchaser and fair to the dealer that the quality should be determined on the coal "as received." In the interest of equity, therefore, the suggestions that follow are presented for the guidance of those who wish to send samples to a laboratory for analysis.

Wagonload Deliveries.—Samples taken from coal delivered at a department building should consist of a shovelful of coal taken from each wagonload or from each third or fifth load, the number of samples taken depending on the loads delivered. It is important to obtain representative portions of coal from every part of the delivery, so that the samples will show the quality of the delivery or order as a whole. The sample should contain about the same proportion of lump and fine coal that is contained in the coal as delivered.

If the quantity delivered is 100 tons or more, at least two samples should be taken, one representing the earlier and the other the later delivery. The average of two or more analyses will represent more accurately the quality of the coal than a single analysis, because it is difficult to preserve the character of the large sample in reducing it to the small sample required for laboratory use.

Cargo Deliveries.—In determining definitely the number of samples to be taken to represent different quantities delivered many variable factors must be considered. For cargoes of 4,000 to 6,000 tons the approved method is to take a sample of about 65 lb. from every third railroad car when unloaded; three such samples, representing nine cars, are mixed and reduced by quartering to the regular 2-lb. sample. By this procedure 8 to 14 samples are obtained for the cargo. An analysis representing the whole cargo is obtained by averaging the results of analyses. It is impracticable to take a single large sample to be fairly representative and reduce it to a 2-lb. sample for laboratory treatment, for the analysis of a single sample would probably not correctly represent the quality of the whole of a large cargo.

Stowage and Quartering Down.—A gross sample should, when taken, be immediately placed in a metal receptacle having a tight-fitting cover and a first-class lock, and when samples are being quartered down each receptacle should be securely locked and the key held by a responsible employee. The receptacle

should be placed in a comparatively cool place to minimize loss of moisture from the sample; and for the same reason the process of quartering down and preparing samples for shipment to the chemical laboratory should be carried on as rapidly as possible. This process, briefly described, is as follows:

The contents of the receptacle or receptacles are emptied in a clean dry space, preferably on a sheet iron plate of suitable dimensions, so located as to prevent admixture of foreign matter with the sample during its preparation. All the lumps are then broken by a maul or sledge until they will pass through a half-inch mesh. The mass is then thoroughly mixed, formed in a conical pile, and equally quartered by means of a shovel or board. Two opposite sections are next rejected and the remaining sections are mixed. The pile is then reformed and opposite quarters are discarded as before. This process is continued until only about 2 lb. remain. This final sample is immediately placed in a suitable receptacle for shipping and is sealed air tight. The metal can in use by the Bureau of Mines for this purpose is 9 in. high and 3 in. in diameter.

Shipment.—The 2-lb. samples thus prepared should be forwarded promptly and notice of shipment sent under separate cover. Receptacles should be marked plainly on the outside and a corresponding number or description should be placed inside. A complete record of all deliveries should be kept, showing dates, names of contractor, kind of coal, total weight delivered, condition of coal (wet or dry) and any other important details.

Sampling Fuel Oil, Etc., for Analysis

The following directions are taken from Technical Paper No. 3, 1911, of the Bureau of Mines of the U. S. Department of the Interior. They apply more particularly to the sampling of petroleum and fuel oil for purchase by the government. They will be found, however, to contain valuable hints for collecting samples of all material of a similar nature.

The same bulletin contains directions (which were not deemed of sufficient general interest to incorporate in this work) for the sampling of natural gas, and also includes specifications for the purchase of fuel oil for the government.

General Statement.—The accuracy of the sampling and, in turn, the value of the analysis must necessarily depend on the integrity, alertness, and ability of the person who does the sampling. No matter how honest the sampler may be, if he lacks alertness and sampling ability, he may easily make errors that will vitiate all subsequent work and render the results of tests and analyses utterly misleading. A sampler must be always on the alert for sand, water, and foreign matter. He should note any circumstances that appear suspicious, and should submit a critical report on them, together with samples of the questioned oil.

Sampling Wagon Deliveries

Sampling with a Dipper.—Immediately after the oil begins to flow from the wagon to the receiving tank, a small dipper holding any definite quantity, say 0.5 liter (about 1 pint), is filled from the stream of oil. Similar samples are

taken at equal intervals of time from the beginning to the end of the flow—a dozen or more dipperfuls in all. These samples are poured into a clean drum and well shaken. If the oil is heavy, the dipperfuls of oil may be poured into a clean pail, and thoroughly stirred. For a complete analysis the final sample should contain at least 4 liters (about 1 gallon). This sample should be poured into a clean can, soldered tight and forwarded to the laboratory.

It is important that the dipper be filled with oil at uniform intervals of time and that the dipper be always filled to the same level. The total quantity of oil taken should represent a definite quantity of oil delivered and the relation of the sample to the delivery should be always stated, for instance: "1-gallon sample representing 1 wagon load of 20 barrels."

Continuous Sampling.—Instead of taking samples with a dipper, it may be more convenient to take a continuous sample. This may be taken by allowing the oil to flow at a constant and uninterrupted rate from a 1/2-inch cock on the underside of the delivery pipe during the entire time of discharge. The continuous sample should be thoroughly mixed in a clean drum or pail, and at least 4 liters (about 1 gallon) of it forwarded for analysis. A careful examination should be made for water, and if the first dipperful shows water this dipperful should be thrown into the receiving tank and not mixed with the sample for analysis.

Mixed Samples.—If the oil delivered during any definite period of time, say 1 month, be from the same source and of uniform quality (but only in case it is of uniform quality), it may suffice to pour definite proportional quantities of the dipper and the continuous samples taken during this period into a tinned can or drum having a tight screw cap or bung. An iron drum should not be used, since even a clean iron surface will absorb sulphur by long contact with a sulphur-containing oil, and this sulphur will be lost to the analyst. At the end of the month a number of round, clean stones should be put into the drum and the drum should be rolled to insure intimate mixing. Then 4 liters (about 1 gallon) of the gross sample should be taken for analysis. The drum should be drained, rinsed clean with gasoline, dried, and made ready for a second sampling.

The all-important point is that the gross sample, whatever the manner of sampling, shall be made up of equivalent portions of oil taken at regular intervals of time, so that the sample finally forwarded for analysis will truly represent the entire shipment.

Sampling a Large Tank or Reservoir

Water or earthy matter settles on standing. Hence before a large stationary tank or a reservoir is sampled the character of the contents at the bottom should be ascertained by dredging with a long-handled dipper, and the contents of the dipper should be examined critically. If a considerable quantity of sediment is brought up, it should be cause for rejecting the oil.

The sampling of a large stationary tank or reservoir of oil, particularly if the oil has stood so long that it has begun to stratify or form layers of different density, may be done as follows:

The sampler should procure an ordinary iron pipe, or preferably a tinned tube, 1 in. in diameter and long enough to reach from above the manhole, where he can grasp it, to the bottom of the tank. The lower end of the pipe should be reamed out with a round file. A conical plug of cork, wood, or other suitable

material should be fitted to this end, and a strong, stiff wire, such as the ordinary telegraph wire, run through this plug and up through the pipe to a point where it can be grasped firmly by the sampler. A pull on the wire will close the bottom of the pipe, and a rap against the bottom of the tank will drive the plug home and make an oil-tight seal or valve.

To operate this sampling device, the sampler should remove the plug, allow it to drop some 3 in. below the bottom of the pipe, and let it hang there by the wire extending above the pipe. Then holding the pipe, open at top and bottom, in a vertical position, the sampler should allow it to sink slowly through the oil to the bottom of the tank. He should do this slowly and with care, so that the pipe will penetrate the oil without agitating it and will thus cut a representative core of oil from the surface to the bottom. When the pipe touches the bottom, the sampler should draw up the slack of the wire and pull the plug into place; then he should strike the plug smartly against the bottom of the tank, thereby driving it home and sealing the pipe. He can then withdraw the pipe and pour the oil into the sampling can. If it seems desirable, he should "core" or "sample" a reservoir at regularly spaced points, unite these samples, mix them thoroughly, and take 4 liters (about 1 gallon) of the gross sample for analysis.

Instead of a pipe sampler, a bottle holding half a liter (about 1 pint) may be used. It should be securely fastened to a long pole and have a loosely-fitted stopper tied to a strong cord. The bottle, corked and empty, is immersed to any desired point within the mass of the oil, and the stopper is pulled out. The bottleful of oil is poured into a suitable receiving vessel, and the bottle, thoroughly drained, is made ready for a second filling. Bottlefuls of oil taken in this way from points symmetrically placed throughout the mass of the oil, will, if properly mixed, provide an excellent gross sample from which to take the 4-liter (1 gallon) sample for analysis.

Sampling a Single Drum

A single drum may be sampled with a glass tube. This tube, open at both ends, should be grasped at the top, held vertically, inserted in the drum without agitating the oil, and allowed to cut its way slowly to the bottom of the drum. The upper end should then be closed with the thumb or forefinger of the hand holding it, the tube withdrawn, and the oil on the outside wiped off with the fingers of the other hand. The sample in the tube can then be transferred to a small can, and forwarded for analysis.

Forwarding Samples

The sample should be forwarded in a glass bottle or carboy or in a tin can, preferably in the latter because less liable to breakage. If a tin can is used the cap should be soldered tight. The can should not be filled completely; about an eighth of an inch of space should be left to allow for possible expansion of the oil.

The can should be sealed as soon as it is filled to avoid loss of volatilization of the lighter constituents of the sample. After the can has been filled and tightly soldered, it should be wiped clean and carefully examined for pinholes or small leaks. All leaks should be soldered before the can is packed for shipment.

The bottle or can should be carefully labeled. The following form of label,[1] used by the Bureau of Mines, should be placed on samples shipped to the bureau:

Department of the Interior

Bureau of Mines

Information to accompany each sample of fuel petroleum submitted for analysis

Sample number . . . . . Sampled by . . . .
Oil delivered to . . . .
(Department receiving.)
Place of delivery . . . .
(City.) (State.)
Quantity of oil delivered . . . .
Date of delivery . . . . . Temperature of oil as delivered. . . . °C
Name of contractor . . . .
Nature of oil . . . .
(Crude, residue, or distillate.)
If refined to any degree, state name and location of refinery. . . . .
. . . .
Source of oil . . . .
(Lease.) (Field or district.) (County.) (State.)
Remarks: . . . .
. . . .
. . . .
Date of forwarding sample . . . .
Forwarded by . . . . , via . . . .
(Express or fast freight.) (Transportation line.)
. . . .
Date of receipt of sample by Bureau of Mines . . . .
Condition of sample when received by Bureau of Mines . . . .
. . . .

The label should be carefully written with a hard lead pencil on a strong mailing tag, and this tag should be securely tied to the can. The lead pencil should be pressed firmly against the tag so as to indent its surface. An inscription thus written is legible even after the paper has been wet with oil. Gummed labels should not be used; they are easily detached if slightly moistened, and may be lost. A duplicate copy of the record on the label should be mailed to the engineer in charge, Bureau of Mines, Pittsburg, Pa.

Sampling Cement

The following recommendations are taken from the report of the Committee on Uniform Tests of Cement of the Am. Soc. of Civil Engineers as amended Jan., 1908.

"1. **Selection of Sample.**—The selection of the sample for testing is a detail that must be left to the discretion of the engineer; the number and the quantity to be taken from each package will depend largely on the importance of the work, the number of tests to be made and the facilities for making them.

"2. The sample shall be a fair average of the contents of the package; it is recommended that, where conditions permit, one barrel in every ten be sampled.

[1] These labels will be furnished on request.

"3. All samples should be passed through a sieve having twenty meshes per linear inch, in order to break up lumps, and remove foreign material; this is also a very effective method for mixing them together in order to obtain an average. For determining the characteristics of a shipment of cement, the individual samples may be mixed and the average tested; where time will permit, however, it is recommended that they be tested separately.

"4. Cement in barrels should be sampled through a hole made in the centre of one of the staves, midway between the heads, or in the head, by means of an auger or a sampling iron similar to that used by sugar inspectors. If in bags, it should be taken from surface to centre."

A **sampling iron** is shown in Fig. 98; the point is an auger, enabling one to bore through the staves.

Inasmuch as a mixture of samples will not reveal irregularities in quality, it is best (except as noted above) to keep samples separate. Each sample should be dated and tagged with the car number and initials, so that it can be positively identified with the shipment it represents.

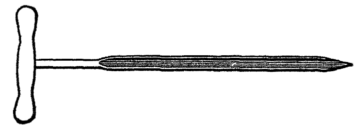


FIG. 98.—Sampling iron for cement testing.

The **quantity of each sample** will depend on the conditions given in clause No. 1 above, but it will usually be about 8 or 10 lb. Mason (fruit) jars make good sample jars. (Richards and North "Manual of Cement Testing;" Van Nostrand, 1912.)

SAMPLING SAND FOR TESTING FOR USE IN CONCRETE

In the "Engineering News" for Feb. 5, 1914, p. 306, is an article entitled "The Testing of Sand for Use in Concrete, I. Field and Laboratory Practice" by Mr. Cloyd M. Chapman, in which is described the methods in use by Messrs. Westinghouse Church Kerr & Co. Below is reproduced the portion of the article dealing with the method of taking the sample in the field. Mr. Chapman emphasizes the importance of care in this part of the work, showing that "the value of a test is entirely dependent upon the degree of accuracy with which the sample of sand represents that from which it was taken," and that "to test an improperly taken sample of sand is not alone a waste of the time and money involved in making the test but may lead to much greater loss if the results of the test are used in specifying proportions for large quantities of concrete."

While not stated directly in the text, it may be noted that the **size of sample** which is to be shipped to the laboratory is given on the "Sand Shipping Notice" as being **4 quarts.**

Taking Sample in Field and Shipping.—Container.—Air-tight cans having tight fitting covers or corks should be provided for shipping samples from the field to the laboratory. A wood covered or crated air-tight metal can makes a very satis-

factory container, which can usually be used over and over again. Avoid shipping samples of sand in bags, in cigar boxes or other wood containers, as they allow the sand to dry out before being tested.

Sampling Before Shipment.—When it is practicable to keep an inspector at the sand bank at all times while shipments are being loaded, so that it may be positively known that the sand which is sampled is the sand which is shipped, then samples should be taken at the bank before loading. Or, if sand is obtained from a source which is known to produce no poor sand, has no spots or streaks of poor sand, has no overburden of loam or other objectionable material which might become mixed with the sand before it is shipped, and is in all respects a deposit from which a uniform grade of sand may be depended upon, then the samples may be taken at the bank without the maintenance of an inspector at the bank.

Taking Sample of Bank.—In sampling a bank of sand which has exposed vertical or steep sloping faces a small channel of uniform size is scooped out of the face from bottom to top. Fig. 1 (not reproduced; Auth.) shows a sample being taken in this manner. The sand scooped from this vertical channel, if more than enough to fill the container, is thoroughly mixed and reduced by quartering to the quantity desired. A tin dipper or can is a suitable tool with which to cut out the sample. By cutting such a groove or channel at each of the faces in the bank from which sand is obtained, samples are secured which represent with a fair degree of accuracy the sand in the bank. The samples taken from the various faces are not to be mixed together, but are marked for identification as to location and sent separately to the laboratory for examination.

If the bank contains both good and poor sand, and it is necessary to maintain an inspector at the bank to insure the shipment of good sand and to sample the sand to be shipped, then the samples may be taken from the piles or bins of sand being loaded.

Taking Sample from Piles at Bank.—Samples are taken with a small tin box such as a pepper or spice box, holding half a pint or less. With this small receptacle portions of sand are scooped up from many parts of the sand pile, filling the receptacle each time and emptying it into the larger can in which it is to be sent to the laboratory. The number of samples to be sent to the laboratory is very largely a matter of judgment on the part of the inspector. Whenever there is any doubt as to the quality of any shipment of sand, a separate sample should be taken of that shipment.

Taking Sample on the Job.—In sampling sand after its arrival on the job, the same general rules are to be followed. A small receptacle such as a glass tumbler or tin box holding not more than half a pint should be used, and the can which is to be sent to the laboratory is filled by taking sand from as many parts of the pile as is necessary to fill it. The sample should be taken from the inner part of the pile as the outer part and especially what rolls down the outside, may be composed largely of the coarser grains or pebbles.

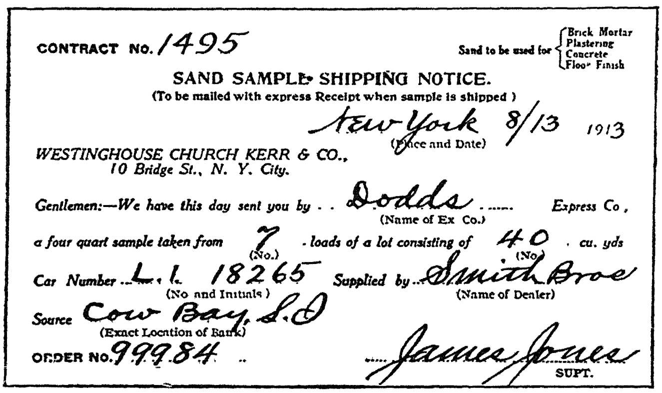
Taking Samples after Delivery.—Samples should be taken from the shipments of sand as they arrive on the job. A preliminary inspection is to be made of the lot, whether wagon loads, carloads, barge loads, or other sort of shipment, to ascertain whether the sand appears to be all of a uniform quality and size. If the various units of the shipment seem to vary, a separate sample shall be taken of each unit and the units shall be kept separate until the sample has been examined

and reported upon by the laboratory. For instance, if two carloads of sand are received, one of which is evidently finer than the other, then a separate sample shall be taken of each car, and if it is necessary to unload the cars at once they shall not be unloaded onto the same pile but shall be kept separate, provided there is any doubt in the inspector's mind as to the suitability of either sand for the work in hand. The samples shall be taken if possible during the unloading, when the shipment is in cars or barges, or from the pile after the wagon has dumped when the sand is received in wagons.

Marking and Shipping the Sample.—To the can containing the sample is securely attached a shipping tag giving the name or number of the job from which the sample is shipped, the name of the dealer furnishing the sand, the quantity of sand in the shipment represented by the sample, the exact location of the bank or deposit from which the sand was shipped, and the signature of the inspector who took the sample.

The sample is then shipped by express to the laboratory for examination.

At the same time that the sample is shipped, all of the above information relative to the sample shall be sent by mail to the laboratory on the Sand Sample Shipping Notice, so that in case the tag on the can becomes defaced or torn off, the information required will still be available. Fig. 99 shows a facsimile of such a notice properly filled out.


CONTRACT NO. 1495 Sand to be used for {Brick Mortar / Plastering / Concrete / Floor Finish}

SAND SAMPLE SHIPPING NOTICE.

(To be mailed with express Receipt when sample is shipped)

New York 8/13 1913
(Place and Date)

WESTINGHOUSE CHURCH KERR & CO.,
10 Bridge St., N. Y. City.

Gentlemen:—We have this day sent you by Dodds Express Co,
(Name of Ex Co.)

a four quart sample taken from 7 (No.) loads of a lot consisting of 40 (No.) cu. yds

Car Number L. I. 18265 (No and Initials) Supplied by Smith Bros (Name of Dealer)

Source Cow Bay, L.I (Exact Location of Bank)

ORDER NO. 99984 James Jones SUPT.

FIG. 99.—Facsimile of sand shipping notice, used in sand testing, Westinghouse Church Kerr & Co. (Actual size of card 3 × 5 in.)

General Cautions.—The sample must truly represent the average of the entire shipment, or that part of the shipment from which it is taken.

The sample must be put into the air-tight container as fast as it is taken from the pile, so that it shall not have time to lose any of its moisture.

The container must be well corked or sealed before shipment to the laboratory.

Collection of Samples of Water or Sewage for Analysis

The following directions are taken from the "Standard Methods for the Examination of Water and Sewage" published by the American Public Health Association.

Quantity of Water Required for Analysis.—The minimum quantity necessary for making the ordinary physical, chemical, and microscopical analysis of water or sewage is 2 liters (0.528 gal.); for the bacteriological examination, 2 oz. In special cases larger quantities may be required.

Bottles.—The bottles for the collection of samples shall have glass stoppers except when physical or microscopical examinations only are to be made. Pottery jugs or metal containers shall not be used.

Sample bottles shall be carefully cleansed each time before using. This may be done by treating with sulphuric acid and potassium bichromate, or with alkaline permanganate, followed by a mixture of oxalic and sulphuric acids, and by thoroughly rinsing with water and draining.

When clean the stoppers and necks of the bottles shall be protected from dirt by tying cloth or thick paper over them.

For shipment bottles shall be packed in cases with a separate compartment for each bottle. Wooden boxes may be lined with indented fibre paper, felt, or some similar substance, or provided with spring corner strips, to prevent breakage. Lined wicker baskets also may be used.

Bottles for bacteriological samples, besides being washed, shall be sterilized with dry heat for 1 hour at 160° C., or in an autoclave at 120° C. for 15 minutes. For transportation they may be wrapped in sterilized cloth or paper, or the necks may be covered with tinfoil and the bottles put in tin boxes. When bacterial samples must of necessity stand for 12 hours before planting, bottles holding more than 4 oz. shall be used.

Time Interval between Collection and Analysis.—Generally speaking, the shorter the time elapsing between the collection and the analysis of a sample, the more reliable will be the analytical results. Under many conditions, analysis made in the field are to be commended, as data so obtained are frequently preferable to those made in a distant laboratory after the composition of the water has changed en route.

The allowable time that may elapse between the collection of a sample and the beginning of its analysis cannot be stated definitely, as it depends upon the character of the sample, and upon other conditions, but the following may be considered as fairly reasonable maximum limits under ordinary conditions:

Physical and Chemical Analysis

Ground waters	72 hours
Fairly pure surface waters	48 hours
Polluted surface water	12 hours
Sewage effluents	6 hours
Raw sewages	6 hours

Microscopical Examination

Ground waters	72 hours
Fairly pure surface waters	24 hours
Waters containing fragile organisms, immediate examination.	

Bacteriological Examination

Samples kept at less than 10° C.	6 hours

If sterilized by the addition of chloroform, formaldehyde, mercuric chloride, or some other germicide, samples for chemical examination may be allowed to stand for longer periods than those indicated, but as this is a matter which must vary according to local circumstances, no definite procedure is recommended.

If unsterilized samples of sewage, sewage effluents, and highly polluted surface waters are not analyzed on the day of their collection, caution must be used in regard to the organic contents, which frequently change materially upon standing. The gaseous contents of samples, especially dissolved oxygen, and carbonic acid should be determined, at once, *in situ* if possible in accordance with the directions given hereafter in connection with each determination.

Representative Samples.—Care shall be taken to secure a sample which is truly representative of the liquid to be analyzed. In the case of sewages this is especially important, in view of the marked variations in composition which occur from hour to hour. Frequently satisfactory samples can be obtained only by mixing together several portions collected at different times or at different places—the details as to collection and mixing depending upon local conditions.

Method of Obtaining Sample of Soil for Analysis

The following method of taking samples of soil for chemical and physical analysis, is extracted from Bulletin No. 70 of the Bureau of Chemistry, U. S. Dept. of Agriculture.

Samples of soil are to be taken in the following manner, and the locality should be selected which is typical of the neighborhood. By means of a spade, from 10 to 20 lb. of soil should be removed from at least half a dozen different points in the field. Select them so as to have them as nearly typical of the whole field as possible. These samples should be put together on a hard, dry floor or oilcloth spread upon the ground, and thoroughly mixed, removing all stones and pebbles, sticks and roots. The residue should then be quartered and one-quarter saved and the other three-quarters rejected. This quarter should again be mixed thoroughly and again quartered and this process continued until the sample weighs 4 lb. or less. This sample should be placed in a strong cloth bag, sewed up, and a label giving the *number* of the sample securely tied thereto.

It is important also to have a sample of the sub-soil in each locality. The samples of the soil are taken to the usual depth of plowing or to where the change in color of the soil is noticed—say, from 5 to 9 in., according to circumstances. After the soil is removed from this excavation carefully, a sample of the sub-soil should be taken to a depth from 5 to 7 in. below the soil sample. The mixing and quartering of the sub-soil should be accomplished in the manner described above.

In each case the previous history of the field, the character of the crops grown on it, and the kind of fertilization, if any, it has received are to be noted. There should also be given any prominent geological features of the neighborhood, the character of the stones and rocks, character of the water, contour of the land, etc.

Accompanying the samples should be sent a memorandum relating to each *number*, stating, in addition to the information outlined above, the locality of the field and whether the sample is of *soil or sub-soil.*

Obtaining Samples of Building Stone for Testing

For Compression Test.—The size of the pieces to be taken will depend upon the capacity of the testing machine. Thus, for a sandstone having a crushing strength of about 10,000 lb. per square inch, a 4-in. cube will require about 160,000 lb. for its destruction, a 2-in. cube a pressure of about 40,000 lb., etc.: 4-in. cubes are the usual size, although 2-in. cubes may be used with fair results. The standard tests adopted in Munich in 1887[1] call for cubes of 7 cm. (2.76 in.). The larger the block the greater the strength per unit of area. The specimens should be dressed and ground, making sure that the pressed faces are as perfectly parallel as possible. It is, of course, not necessary that the blocks be finished to exact figures, as the strength per square inch will be calculated on the cross-section actually stressed.

The **number of specimens** to be taken will depend upon the importance and class of work on which the stone will be used. When preliminary results, or data for ordinary construction only are desired, from three to half a dozen specimens will be sufficient. For work of consequence, and for cases where the important "frost test" is to be made, more samples must be obtained; a maximum number would be, six for the dry compressive test (three normal and three parallel to bed of stone), six for the compressive test on saturated pieces, and six for the compressive test on frozen pieces; eighteen in all.

For Transverse Test.—The specimens should be dressed to 2 in. × 2 in. × 8 in. Three or four or more specimens should be obtained for the test, depending upon the importance of the work.

Notes.—The collector should also observe and report on the following data:

(1) Position in quarry from which specimen was taken. Mark each piece with a number, and furnish a record corresponding to same, giving date, locality, designation of stone, etc.

(2) The effect of "weathering" as shown at quarry face. Note the effect of, (a) the sun, in producing cracks and ruptures, (b) rain and moisture, (c) frost, (d) air, as influencing the chemical composition of the stone (especially in cities).

SEC. II. SAMPLING AND INSPECTING PARTLY WORKED-UP MATERIAL

Inspecting Iron Castings

Test Pieces.—The casual inspector on ordinary work will have nothing to do with test pieces. An inspector stationed to watch important work, however, will have to see them cast and personally verify the correctness of their test. The bars are made in various shapes, specified not to break under certain centrally applied loads; the in-

[1] See Carpenter's "Experimental Engineering."

spector should verify the dimensions of the bars and keep a record of the breaking load and deflection, each piece being marked so as to be identified with the material of the same pouring. The number of test bars to be poured will depend upon the conditions; Byrne recommends that the bars be cast alternately before and after each casting, with at least one test bar for each 2,000 lb. of castings; the A.S.T.M. specifications call for "two sets of two bars—from each heat, one set from the first and the other set from the last iron going into the castings. Where the heat exceeds 20 tons, an additional set of two bars shall be cast for each 20 tons or fraction thereof above this amount."

General.—For notes on iron founding, defects, etc., see Byrne's "Inspector's Hand Book": the following notes relate to certain specific items frequently encountered by the office engineer, not therein mentioned.

Large Pipe Fittings, 24 in. diameter and over for water lines, etc., should be reasonably smooth; they cannot be condemned for **roughness,** but this imperfection frequently points to poor workmanship in other and important particulars. If **thinness** at any point is suspected, have a 3/8-in. hole drilled and the thickness of metal ascertained. **Honeycombing** of faced flanges is to be particularly noted, defects outside the bolt-circle may be passed, but sponginess inside the bolt-circle (the gasket face) should be filled with lead and caulked, or the piece condemned, depending on the extent of the flaw and the use of the casting. Small **blow-holes** in the body of the piece may be drilled and plugged with pipe-plugs; small **cracks** may be patched with steel plate, riveted or patch-bolted on. These expedients will often have to be allowed when prompt shipment of material is imperative.

See that fillets are cut away, or **seats "spot-faced"** so that bolts or nuts may come to a good bearing.

It is not always possible to **check all dimensions,** but as much of this work as possible should be done, sufficiently so that no serious errors may be found when erecting which would reflect on the inspector. In shops which inspect their own output (auto-inspection) such checking of dimensions against the drawings may largely be waived, and a lookout need be kept only for such points as are influenced by the arrangement of the connecting machinery and which are not so well appreciated by the manufacturer's inspector.

Large Body Castings for portions of evaporator cells, tanks, etc. The notes given above for large pipe fittings apply equally for this material.

Cast-iron Car Wheels for standard railroad work are bought under very complete and rigid specifications. For tests, etc., see the specifications under which the wheels were purchased, or the Standard specifications for Cast-iron Car Wheels of the Am. Soc. for Testing Materials.

Small wheels for industrial cars, plantation cars, etc., will be subject to superficial test only. Check dimensions with drawing; test for roundness with calipers; if considerable variations occur examine the pattern, which may be old and shaky; weigh a number of wheels and record the unit weight; this figure will be useful in checking invoice and shipping list. Chilling of treads may be tested with a hammer and chisel, compare hardness with that of metal on arms or hub. Large fins and blisters should be ordered to be dressed off. In case of any considerable want of truth (caused, usually, by an old pattern) the whole batch may have to be rejected.

Large Machinery Castings need inspection for quality of iron, soundness and truth. The first is indicated by the behavior of the test piece and the appearance of the fracture. The second is shown by the appearance of the casting, which should be scrutinized closely for cracks or sponginess, especially at the junction of light and heavy sections.

The third item will necessitate a complete checking of the dimensions against those of the approved detail drawing.

Check overall figures; locate and mark centre lines and test for "squareness;" see that there is sufficient material for finishing at all surfaces so marked; check detail dimensions; check for omission of lugs, bosses, etc.

Light Machinery Castings should be inspected in the manner described above for large machinery castings. Attention must usually be paid, also, to the smoothness of the pieces.

Inspecting Steel Castings

The superficial examination of steel castings will be practically the same as for iron castings. For testing, however, the tensile method is used instead of the transverse test; and the results of the chemical analysis are of more value than in the case of cast iron. For small castings, one or more may be broken to ascertain the ductility, strength and freedom from defects of the lot. Large castings should be suspended and hammered all over as a means of locating cracks and flaws. Steel castings can now be produced with a very smooth finish, and any roughness that will detract from the utility of the casting may be a cause for rejection.

For the essential features in the inspection of this material see Byrnes' "Inspectors' Pocket Book," and also the Standard Specifications for Steel Castings of the Am. Soc. for Testing Materials.

Inspecting Steel Forgings

The class of material which the office engineer may be called upon to inspect will usually consist of large forgings for shafts for sugar mills, steamships, engines, etc. The importance of this material is such that

it will usually pay to employ one of the regular inspecting companies to follow the work through the whole progress of fabrication, furnishing a complete, certified record of tests. If this is not done, however, about all that remains for the final inspector to do is to check the dimensions of the piece, witness and mark the cutting of the test specimen, and certify the figures of the test.

Specifications for this material, with methods of obtaining test specimens and making tests, are given in the Standard Specifications for Steel Forgings of the Am. Soc. for Testing Materials.

Inspecting Boiler Plate

The office engineer will occasionally be called upon to inspect plates for boiler fabrication, more particularly material for export. His work, in this case, will consist in seeing that the material is properly stamped, inspecting the test sheets, and verifying the dimensions and number of sheets.

The Manufacturers' Standard Specifications call for all plates to be **stamped** with the melt number, while the Massachusetts Boiler Laws (under which much material is purchased) call for a stamp giving the name of the manufacturer, place where manufactured, brand and lowest tensile strength, to be placed so that it may be readily visible when the material is riveted up.

A **record of tests** on each heat or melt is made by the manufacturers, and copies should be obtained by the inspector and scrutinized for compliance with the limits of values, analysis, etc., given in the specifications. An affidavit of the accuracy of the test sheets should also be obtained as part of the record.

The **dimensions** and **number** of sheets should be checked against the list or drawing in the usual way.

For detailed instructions concerning the "Mill Inspection" of steel, see Byrne's "Inspectors' Pocket Book."

Inspecting Tank Steel Plates

Tank steel plate is often material which will not pass the tests for boiler plates, but which is sufficiently good for all ordinary tank pressures. It will usually stand flanging hot, but the poorer qualities are apt to be brittle and seamy, cracking easily on the bending tests.

The casual inspector of this material should view both sides of the plate for slivers and seams, rejecting such material as will evidently not work up into presentable tanks, etc. Also the sheets should be carefully tested for thickness, especially when the material is bought by size and thickness. Micrometer calipers or wire gauges may be used, or pieces may be measured and weighed and the weight per square foot calculated.

Material, especially when partly or wholly fabricated, cannot well be rejected for being slightly under gauge; representations may be made for a reduction in the contract price, however, and the moral effect, in connection with future work, will be of value.

Mill Inspection of Structural Steel Shapes

This work, when performed at all, is invariably carried out by the agents of the large inspection companies. Their inspectors keep track of the material as it goes through the mill, witness tests, collect and forward test sheets, make a surface inspection of the finished material, and forward progress reports to the home office. On important work it is very desirable that such a supervision of the fabrication of the material be exercised. On the ordinary run of small work, however, mill inspection of structural steel by the buyer is the exception, and the uniformity of manufacture today is such that it is not necessary. On request, the steel mills will supply copies of the test sheets and affidavits of their accuracy, and, on bridges, etc., of any importance, these sheets should be obtained and scrutinized.

Inspection of Structural Timber

This work is a trade in itself, and the office man cannot, offhand, presume to undertake the classification and approval of a shipment of lumber. He should, however, with the aid of the information referred to below, be able to prevent the passing of very many inferior sticks.

"Dimension lumber," cut to length for bridge construction, etc., should be carefully checked for correct dimensions and suitability for purpose intended. If timbers are to be finished to exact length ordered (say, for example, 18 ft. 0 in.), it will be necessary to specify especially in the order that these pieces must not under-run the ordered length, otherwise some sticks may be tendered slightly scant in length. A certain amount of scantiness in width is allowed by the various rules.

For a very complete and detailed description of **defects in lumber** and of **its classification,** see Byrne's "Inspectors' Pocket Book." Also see the rules of the various lumber manufacturers' associations, and the Standard Classification of Structural Timber issued by the Am. Soc. for Testing Materials (this gives very clear photographs of standard defects).

For further notes see article on "Ordering Lumber," p. 208.

SEC. III. INSPECTION OF PLANS AND DETAIL DRAWINGS

Inspection of Engineering Designs

For checking such designs, whether drawings, specifications or existing structures, the "reminders" given in Chapter II (Designing and Drafting Systems) may be followed. This part of the work is, of course,

of a more or less routine nature; but the broader features of the suitability of the design as influenced by financial considerations, probable future disposal, present and future legislation, etc., must not be lost sight of. Ripe judgment and experience will govern the latter considerations, and no set rules can take the place of these possessions.

Inspection of Detail Drawings

This work forms an important part of the routine in Inspecting and Consulting Engineering Offices, especially so since the recognition, in the last 15 or 20 years, of the fact that the strength and durability of engineering structures depends very largely on the proper design of their details.

It has become the custom therefore, in almost all modern specifications for either structures or machinery, to call for **detail (shop) drawings to be submitted to the engineers for approval.** These drawings are called for in duplicate, one to be returned to the contractor with changes, etc., marked thereon, and the other, similarly marked, to be retained by the engineer for his file. Drawings that are passed are marked "Approved," those with minor changes "Approved as Modified Above," and those that show a non-acceptable design "Not Approved," in each case followed by the dating, official stamp of the engineers, and the initials of the inspector (see p. 314). This system enables the engineer to keep absolute control of the design, and, at the same time, protects the contractor in case of any future question as to the suitability of the work as constructed. It is always understood (although a clause to the effect should always be inserted in the specifications) that "the contractor shall be responsible for dimensions and details on the working drawings and the approval of these detail drawings by the engineer shall not relieve the contractor of this responsibility."

In the case of standard machinery, such as small pumps, etc., or of special, patented apparatus, it is usually not necessary or customary to ask for such drawings; and, indeed, such a demand would probably be met by a refusal, as the manufacturer is invariably willing to take the responsibility for the proper working of his apparatus.

For "**reminders**" for checking detail drawings, see Chapter II (Designing and Drafting Systems).

Also see the example of **general instructions** for inspecting such drawings for approval, in the following article.

Inspection of Structural Steel Shop Drawings for Approval

The examination of the shop drawings is not to be a check of the detailed dimensions for which the Bridge Co. is held responsible, but is to cover the following points for which the engineers are responsible.

I. Structures to be erected by the contracting Bridge Co.

(1) Check size and location of members from general drawings or strain sheets.

(2) Check strength of connections from general drawings, strain sheets and specifications. This includes a general examination of details to see that they are well proportioned and are not too light or excessively heavy.

(3) Check important overall dimensions of members.

(4) Check fit of steel details to work of other contractors.

(a) Mason. Covering over steel; size of column bases, and bearing plates; location of anchors, wall supports, tie rods, finish angles, lintels, etc.

(b) Carpenter. Fit of wood work and connections to steel

(c) Sheet metal work. Attachment and clearance for same.

(d) Mechanical equipment. Connections and clearances.

II. Structures to be erected by the Engineers, or their sub-contractor

(1) to (4). Same as above.

(5) Examine connections to see that members can be easily erected and riveted; see that parts are so laid out that labor of erection and riveting is as small as consistent with good work.

(6) See that all material called for on general drawings or listed in specification is listed by shop drawings. This will include all such material as fittings, field rivets and fitting-up bolts for erection.

III. General

The above points should be given as much attention as the job in hand warrants, keeping in mind the necessity of not delaying the return of approved prints any longer than absolutely necessary. All checks should be done on *retained print* and only corrections noted on *returned print.*

After corrections are decided on, *both prints* should be marked near the title as follows:

APPROVED
BLANK
IRON WORKS CO.
.. ENGINEERS ..
NOV. 1, 1913
29 BROADWAY
NEW YORK
(*a*)

or,

APPROVED AS
MODIFIED ABOVE
(Stamp)
(*b*)

NOT APPROVED
(Stamp)
(*c*)

FIG 100.—Stamps for approval of contractor's drawings.

followed by the initials of the checker.

SEC. IV. INSPECTING AND TESTING FINISHED MATERIAL

General Remarks

This work, on the part of the office engineer, will usually take the form of a visit to the works of the manufacturer just prior to the shipment of the material or finished machine. This method of inspection

is not very satisfactory, as it is usually out of the question to reject the shipment on account of the necessity of meeting scheduled dates; it is better to make two or three inspections during the fabrication period, as there will then be time for the replacing of faulty material. In case a final inspection only is made, the engineer's work will usually consist in a general check for dimensions and workmanship, the witnessing of test runs, and the securing (on export shipments especially) of compliance with the specified requirements concerning packing, marking and shipping.

Inspection of finished material for export should be particularly thorough; it is not enough to see that the material presents a workmanlike finish, all main and connecting dimensions must be verified. The writer has had personal experience of a case where a crank-shaft of 12 in. diameter, and weighing 4 tons, shipped from a prominent engine-building firm in this country to the Philippine Islands, was found, on erection, to be 1 ft. 0 in. too short. The mistake originated in the drawing office of the makers, and, owing to the reliability attached to the latter, inspection on the engine was waived by the engineers.

Inspecting Small Steam Engines, Gas Engines, Pumps, Etc.

This class of material is rarely inspected. The units are turned out in such quantities and the business of manufacturing such articles is so systematized that the purchase of a small engine or pump is very similar to the purchase of a hat or other article of every day use; the purchaser "pays his money and takes his choice."

In case, however, it is desired for any reason to inspect such machinery, the inspector may check the dimensions against the contractor's accepted specification, may assure himself that the material is sound and as called for, and may scrutinize the workmanship, proceeding, if desired, according to the outline for inspection of second-hand machinery given in the following pages. The most satisfactory inspection, however, consists in the witnessing of a run under power, taking indicator cards, counting revolutions, and examining for knocks, heating, scoring, etc. Any imperfections thus indicated should be ordered corrected. Capacity or efficiency tests for this small material are out of the question.

It is needless to say that such inspection as is indicated above should be done by a man having a practical knowledge of engine running; examination by one without such experience is of indefinite utility.

Inspecting and Testing Second-hand Steam Engines

The list of inspection items given below is intended to be fairly complete, and it is not often that an opportunity will be afforded for sub-

jecting an engine to examination according to the whole list; the judgment of the inspector, therefore, will have to govern the selection of items to be followed in individual cases.

Inspection

(1) Test **piston end-clearances** by marking ends of stroke on cross-head guides, disconnecting crank-end and forcing piston to heads; clearance will be indicated on guides.
(2) Test amount of **clearance in crank-pin,** main shaft boxes and cross-head pin by shaking, pinching or by a piece of lead wire.
(3) **Examine journals,** boxes, piston rod, valve stem, etc., for scoring.
(4) Take off cylinder head and withdraw piston and rod; examine **piston rings and piston nut;** see whether **cylinder** is scored and examine for truth and wear.
(5) Take off valve-chest cover and examine **valve** for scoring, tightness, equality of leads and laps, etc.
(6) On self-contained engine, test cylinder and shaft **centre-lines for right-angle truth,** either by maker's marks or by usual lining-up methods.
(7) Test **all cocks and valves** for tightness and freeness.
(8) Test **all nuts** with a wrench to see that same are tight; all lock-nuts and cotters to be in place.
(9) Test all **oiling systems** or oil-cups to see if they are free and operate properly.
(10) On **throttling engines,** see that **eccentric** is properly set to give equality of lead and correct direction of rotation.
(11) On **automatic engines,** see that parts of **valve-gear** are set to original marks of engine maker; examine springs, etc., for soundness and tightness.
Note.—A small book on "Shaft Governors" (Hill Pub. Co., 1908) describes and illustrates various forms of shaft governors, and gives practical directions for adjusting them.
(12) On **Corliss engines,** examine wearing surfaces for undue wear; test springs, dash pots, etc.

Test

(13) **Test engine under steam,** at friction and full load, taking **indicator cards** to verify the valve-setting, and R.P.M and cylinder and rod dimensions to calculate the I.H.P. If possible, obtain the B.H.P. output so as to get the amount of engine friction.
(14) During several hours run, test all bearings, etc., for **heating.**

Inspecting and Testing Large Steam Engines, Pumps, Etc.

Inspecting

It is assumed that the material is in the shops, nearly ready for delivery, and that a member of the engineering staff is sent to inspect the engine, pump, etc., so that shipment may be authorized.

In general, it may be stated that all main dimensions must be checked and all material scrutinized for quality and workmanship. A mere cursory examination of the parts, coupled with the trust that the high standing of the manufacturers will ensure satisfactory results, is not sufficient, unless one is willing to run the risk of later criticism for some disastrous mistake, such as the passing for shipment to the Antipodes of

a large crank-shaft 1 ft. too short, which is an actual example of affairs that sometimes do happen.

To the casual inspector, therefore: Prepare a table in advance, based on the specifications, giving blank spaces for all main dimensions and their corresponding fits, such as journals and boxes, etc., and for remarks on kind and quality of material and of workmanship for all important parts; examine the work systematically, and complete the record. A report on the inspection may then be turned in that is *positive*. Also obtain information on the other items mentioned in connection with inspection reports on p. 328.

Testing (General Remarks and Reference)

The test of a large steam engine, steam pump, or complete power plant will usually be conducted for the purpose of ascertaining whether the installation develops the capacity and duty guaranteed. Other objects of such a test are to adjust the valves and working parts, to ascertain the friction for different speeds and conditions, and to determine the most economical operating speed.

The testing force will quite usually consist of a number of fourth-year men from a technical college, working under the direction of a professor or instructor in coöperation with the engineers of the owners and of the manufacturers. Such students are trained to the use of instruments and to testing methods, and no better observers could be desired; and the men in charge will usually be experienced and expert in just this kind of work, so that the results are rarely open to question.

No attempt will be made here to enter into either the method or details of large engine testing; in Carpenter and Diederich's "Experimental Engineering" (John Wiley and Sons, New York) is given a complete description of the methods and operations and of the results to be obtained, and reference to that publication is a *sine qua non* to anyone undertaking testing work of any importance or magnitude.

Inspecting and Testing Second-hand Gas Engines

Gas engines vary greatly in details of accessories, owing to the variety of fuel available; but all are fundamentally alike and can therefore be inspected according to the following schedule. All common defects are summarized, but it is understood that the opportunity is seldom presented to make as thorough an inspection as that outlined.

(1) **Loss of Compression.**—Caused by loose or missing piston rings, cylinder worn out-of-round or scored, pitted or carbonized inlet or exhaust valves. If engine is of small size compression can be tested by turning over by hand, a "rubbery" action indicating good compression. Note that if engine has been standing idle for a long period, the compression may be poor due to draining away of all oil from cylinder and rings.

(2) **Examine engine externally** for water-jacket cracked or filled with sediment, damaged or missing parts, and general suitability for the work intended.
(3) Remove necessary parts to **expose interior of cylinder,** and see that cylinder walls and piston rings have a smooth polished surface.
(4) Take out and examine **valves** for pitting and grooving (exhaust particularly).
(5) Examine **bearings** as far as possible; look for scoring or grooving of journal, and wear in boxes. In two-cycle type with crank-case compression, make sure that main bearings are not slack, allowing escape of gas from crank-case.
(6) **Test** valve-timing, governing, oiling, cooling, and ignition systems **by running engine light.** Groaning gears indicate excessive wear. If not possible to run engine, inspect valve motion, etc., carefully.
(7) If circumstances allow of a **brake test,** the value of the engine may be demonstrated beyond any chance. See Carpenter's "Experimental Engineering" for complete instructions.

Inspecting an Efficiency Test of a Pump

It is assumed that the test is made by the Contractor's forces in the presence of the Engineer's Inspector. For arrangement of apparatus, method of conducting test, recording of observations, method of working up results, etc., see Carpenter's "Experimental Engineering" or other similar Text Book.

(1) Make complete **record** of date, place, weather, temperature of air and water, number of observers, name-plates, and numbers, etc., of all machinery, instruments or other apparatus, and diagrams or sketches illustrating the test.
(2) Insist on proper **length of run,** etc., and put on record at once with the proper authorities any feature prejudicial to a satisfactory test.
(3) Where **water pressures** are measured by a mercury column, see that the proper air-cocks are inserted at tops of bends and note how the columns are graduated, making actual measurements to check the same.
(4) **Record sizes** of suction and delivery pipes, etc.; sizes of manometer pipes and the method of their connection to the mains; sketch and measure discharge nozzle or weir or other apparatus for measuring delivery.
(5) Keep **personal records of readings** during runs sufficient for working up a check result, including R.P.M's.; manometer (suction), delivery, and nozzle pressures; weir readings, etc.; electrical, brake readings, etc.
(6) Obtain such **data** as calibration curves of nozzle, characteristic curves of motor, etc., and where steam is the motive-power obtain indicator cards, etc., as described under tests of that apparatus.
(7) **Centrifugal Pumps** should also be subjected to a hydrostatic pressure for the detection of leaks in the casing and suction chambers which are under atmospheric pressure from the outside while pump is running. This pressure need not be more than 20 lb. per square inch; and, while not a logical test for this class of pump, will sometimes indicate, or account for, a low efficiency due to air leakage into the suction.

Capacity Test of a Steam Turbine; Instructions to Inspector

The representative of the Blank Co. at such a test will submit a report based on the following schedule, which is to be followed in a general way with due allowance for individual cases.

(1) **Describe the apparatus** under test, noting the following points:
  (a) Purpose for which turbine will be used.
  (b) Full title as described by the manufacturer, for instance, horse-power, type, R.P.M., number of stages, steam pressure, cond. or non-cond., and the builder's number of the machine.
  (c) Give full particulars of apparatus to be driven by turbine and state its power requirements.
(2) State guaranteed **capacity,** conditions of steam pressure, etc.
(3) Describe fully the **method of test,** and apparatus and meters used. Copies of calibration tests of meters and efficiency curves of generator (if used) should be obtained.
(4) The Blank Co.'s representative will take a **series of readings** personally; tabulate them, giving place and date of test, any weather conditions affecting the result, time of reading, etc., and compute the results.
(5) A short **summary of results** should be given, pointing out the salient features of the test, and including the inspector's recommendation as to the acceptance of the machine.
(6) **Date of shipment** should be ascertained from some responsible party.
(7) The representative should be on the lookout for any engineering data, etc., and should make a **separate report** on any circumstance or information of probable value to the company.

Inspection of Steam Boilers, New and Second-hand

Inspection of a new boiler built by a reputable firm, on the part of a small engineering office, is rarely undertaken; the results are usually not considered as justifying the expense. It is always possible to obtain an affidavit of the satisfactory performance of such test, and some boiler manufacturers supply, as a matter of course, a certificate of inspection from a firm of boiler inspectors. Some of the cheaper and less known boiler shops, however, will bear watching; one sometimes hears tales of tank steel and other inferior material being used in boilers constructed by such firms.

Table X gives a list of defects discovered in steam boilers inspected by the officials of the Hartford Steam Boiler Inspection and Insurance Co. for the year 1912, and is extracted from the April, 1913, number of "The Locomotive" published by that company. The percentage figures indicate the frequency with which various defects may be expected to occur in American boilers. It will be noted that the majority of troubles have their origin in the feed water, or the method of using it.

In cases where it is desired to make an **inspection, more especially of a second-hand boiler,** the following outline may be followed. It is recommended that, on completion, a report be written out in the form of "Question and Answer," referring to the points taken up below.

(1) Observe the **marks stamped on the plates** by the mill giving heat number and tensile strength, for heads, shell, etc.

(2) Witness **test by hydraulic pressure** to 50 percent more than working. Note whether seams, rivets or tubes leak; mark and have same caulked water-tight.
(3) After satisfactory test, empty boiler and enter; **test all stays** (with a hammer) to see if they are sound. See that **inside** is left clean, especially that it is **free from oil.**
(4) When inspecting old boilers, see if same are **free from scale** or **corrosion, pockets** caused by plates bulging, **loose or broken stays;** examine **tube ends.**
(5) In case of an old boiler, make a **sketch** giving all principal dimensions, drilling the metal in a few places to test its thickness, so that the proper working pressure may be judged from calculation.
(6) Try water column and cocks; calibrate steam gauge; test safety valve to see that it blows off at or near the proper pressure, record size so that its sufficiency may be checked; see that feed pipes are not choked; see that blow-off is not choked and examine particularly for burning and corrosion; examine fusible plugs (and renew); see that stop-valve is tight and free.
(7) Examine **method of suspension** of boiler and see that it is safe, making sketches so that its strength may be calculated.
(8) See that **setting is safe** and tight; **grate** in good condition and suitable for the fuel intended.

Table X.—Summary of Defects Discovered, 1912

Nature of defects	Whole Number		Dangerous	
	No.	Percent	No.	Percent
Cases of adhering scale	40,336	24.5	1,436	7 6
Cases of sediment or loose scale	26,299	16 0	1,553	8 2
Cases of internal corrosion	15,403	9 4	823	4 4
Cases of defective tubes or flues	11,488	7.0	4,780	25 3
Cases of external corrosion	10,411	6 3	895	4 7
Cases of leakage around tubes	10,159	6 2	1,607	8 5
Settings defective	8,119	4 9	768	4 1
Pressure gauges defective	6,765	4 1	568	3 0
Cases of leakage at seams	5,304	3 2	401	2 1
Burned plates	4,965	3 0	517	2 7
Blow-offs defective	4,429	2 7	1,398	7 4
Water gauges defective	3,663	2 2	816	4 3
Fractured plates and heads	3,288	2 0	510	2 7
Cases of grooving	2,700	1 6	252	1 3
Miscellaneous defects	2,268	1 4	420	2 2
Cases of defective riveting	1,816	1 1	405	2 1
Cases of defective staybolting	1,712	1 0	345	1 8
Safety valves defective	1,534	0 9	419	2 2
Cases of defective bracing	1,391	0 8	331	1 8
Safety valves overloaded	1,349	0 8	380	2 0
Other defects (listed in original)	1,525	0 9	308	1 6
Total	164,924	100 0	18,932	100 0

Inspecting and Testing New Electrical Material

Apparatus

The ease and certainty with which tests can be made on electrical apparatus has had a great influence on the present perfection of the

material. The manufacturer can readily make complete tests, thus preventing the shipment of imperfect material; furthermore, if such material is installed its defects become manifest very quickly, so that care on his part is essential.

Manufacturers of first-class apparatus conduct shop tests in accordance with the "Standardization Rules of the American Institute of Electrical Engineers," which consist, in general, of high potential tests between windings and frame, and full load and overload runs to insure that the machine meets temperature-rise guarantees. There are a few makers of cheap machinery who do not make adequate tests of their output. The product of such shops can only be valued by complete tests and expert observation of shop methods.

As a general rule, however, it may be stated that the manufacturer's test results may be accepted without question; except for special machines of great importance, when certified tests should be obtained, wherein the manufacturer's tester swears to the report of test before a notary public.

If an inspection is made of this class of material the duties of the inspector may be confined to the following:

(1) See that **order** has been **correctly filled** in regard to type of apparatus, etc.
(2) Examine **packing for protection** against breakage and moisture, bearing in mind that it may be exposed to storms with no protection except the packing.
(3) Find out from a responsible party when **shipments** will be made.

Supplies

Electrical supplies of all kinds should be specified to meet the requirements of the "National Board of Fire Underwriters," and should be approved devices bearing the inspection tag or label of the "Underwriters Laboratories, Inc."

The inspector's duties will then consist of simply making sure that all material is of "approved" make and that it is adequately packed.

Inspecting and Testing Second-hand Electrical Apparatus

Small motors, etc., if bought locally, may be purchased subject to payment when machine is in satisfactory operation.

More important apparatus, such as medium-sized generating-sets, etc., when purchased from second-hand machinery dealers for shipment to a distance, should be inspected and tested as fully as circumstances will permit, according to the following schedule:

(1) Examine machine and accessories for **damaged or missing parts** and general suitability for the work intended.
(2) See that **journals** are not grooved or scored, **bearings** not worn, and that **oil rings** are free, etc.

(3) On commutating machines a large percentage of all possible troubles manifest themselves at the **commutator,** and the condition of this part is a good indication of the past service and present condition of the apparatus.
The commutation should have a smooth, true cylindrical surface, of a dark mahogany color. If it has been newly turned down, it indicates that it has developed some of the following defects:
   (a) Worn in wide grooves due to many years service, or to the use of improper brushes.
   (b) Burnt from arcing due to long-continued overload.
   (c) Burnt from arcing due to the numerous possible troubles in the machine itself.
   (d) Poor mechanical construction or uneven wear of mica and copper.

(4) **Run the machine at no load** to ensure that all parts function properly.
(5) If circumstances allow of a **full-load test,** the worth of the apparatus can be demonstrated beyond all doubt. See "Electrical Engineers' Pocket Book" by Foster; D. Van Nostrand Co.

Inspecting Conveying and Elevating Machinery

The inspector should work to the original engineer's drawings for checking the main dimensions and field connections, so that points overlooked by the contractor's draughtsman may be caught. For the details, the approved detail drawings may be followed.

(1) Verify the **main (c. and c. and overall) dimensions.**
(2) Check the **principal detail sizes,** such as diameter of scrolls, depth and width of trough, width of elevator, size of openings, drop of hangers, etc.
(3) Check the **thickness of plates,** size of chain, diameter of sprockets.
(4) Pay special attention to **details which connect to the work of others,** assuring yourself that the material will go together properly.
(5) Have several (or all) of any **special gates assembled** and operated, to make sure that they work easily and without interference.
(6) Also see that **special devices** (such as trolleys on circular track, etc.) operate satisfactorily.
(7) See that **all material has been supplied** as called for by the specifications.
(8) Verify the **color of paint** used and manner of **marking for erection and shipping,** and see that material is suitably **packed for shipment** (see p. 376).
(9) Render a **report** on form such as is described on p. 328.

Shop Inspection of Piping Installations

When the size and importance of the contract warrants the use of a permanent inspector, his work will consist in making a complete check of the material of the installation, quality of materials, all lengths, detail dimensions, workmanship, marks, etc., etc., in the manner and with the same thoroughness that is usual in structural steel fabrication. It is, of course, necessary that the inspector have a wide enough knowledge of shop methods on this work to enable him to pass or reject material with intelligence.

On many jobs, however, it will be sufficient to send an inspector to

the shops at intervals, when material has accumulated to a convenient extent, and the following reminders are intended to aid the office man who may have to make such intermittent inspections.

It is assumed that the material is being produced from complete engineer's designs, *i.e.*, drawings giving all principal dimensions and sizes but not giving detail dimensions of standard fittings, etc., and that inspecting is done to these drawings and the specifications.

(1) In general, do *not* attempt to check **lengths of piping**; the results will usually be inadequate, and any mistake can often be easily corrected in the field. An exception may be made in the case of pipe with welded flanges, on which field alteration would be difficult and results probably dangerous.

(2) In general, do *not* attempt to check **quantities**, as any short shipment can better be caught by checking the shipping list.

(3) Pay special attention to all **special material** such as reducing flanges, taper reducers, side-outlet fittings, special-angle elbows, manifolds, extended stems and chain-wheels on valves, etc., etc., as these are the parts on which mistakes are most liable to be made, and which are hard to correct in the field—check completely.

(4) **Bends and offsets**, check completely.

(5) **W. I. or Steel Flanged Pipe.**—See that flanges are of type called for in specifications, check for dimensions and drilling, and smoothness of facing. Check thickness of a few pieces of pipe by measuring inside and outside diameters.

(6) **Flanged Fittings.**—Look over for weight, truth, and freedom from cracks or holes. Check flange-dimensions of selected fittings, and note correctness of any reductions in tees or crosses.

(7) **Valves.**—See that these are of the style and grade specified, and check flange dimensions of selected pieces.

(8) **Screwed Fittings.**—Examine for truth, soundness and condition of threads, a sufficient proportion of the lot.

(9) **Brass Fittings.**—Examine valves for truth, soundness and workmanship; second-grade and absolutely defective material is particularly apt to occur in these fittings.

(10) **Cast-iron Pipe.**—Bell and spigot cast-iron pipe is usually the subject of standard specifications which describe in detail the requirements and allowable variations. The "Standard Specifications for Cast-iron Pipe and Special Castings" of the Am. Soc. for "Testing Materials" are an example, and may be referred to by the inspector on this class of material.
Flanged cast-iron pipe may be inspected for similar requirements, and also for flange-dimensions, length, etc., according to conditions.

(11) **Riveted Pipe.**—Check diameters, lengths, thickness of metal, rivet-spacing, size of rivets, etc., as far as may be necessary to see that specifications and drawings have been followed. See that caulking is workmanlike. Pay particular attention to flanges, not only dimensions and drilling, but, more particularly, the truth and finish of the faces, and reject unequivocally any pieces that will not pull up to a tight and true joint. See that material has been properly dipped or painted.

(12) Examine all **gaskets**, to see that they are of the grade and thickness specified.

(13) See that **bolts and nuts** are of the style and finish specified.

(14) **Marking.**—The proper marking of this material is a matter of supreme importance. See that marks are correct and indelible; it is often desirable to place marks on large fittings both on inside and outside.

(15) **Packing.**—This is of special importance on export work; see that specifications have been complied with.
(16) **Delivery.**—Ascertain what proportion of the work has been completed and whether shipment will be made on schedule time. Observe particularly the progress made on any parts that are wanted in advance of the main shipment, or which, by their difficulty of construction, are liable to be delayed.
(17) **Take notes** of all errors or unsatisfactory material and report on in writing on the regular forms (see p. 328).

Inspecting Hand-power Overhead Traveling Crane

The building of hand-power overhead traveling cranes has become such a standardized operation, that inspection of material for domestic service is usually waived; the makers are invariably willing to replace at once any defective material. On export work, however, it is usually more satisfactory to all concerned for the engineer to satisfy himself that the main dimensions, clearances, etc., conform to the drawings. It is not always possible to make a loading and operating test in the shop, so that, for the strength and working qualities of the crane, the engineer usually has to rely on the experience and skill of the maker; as, on these small items, manufacturer's quotations are invariably f.a.s. shipping port, no part of the payment being contingent on test and satisfactory operation in a foreign country. If required, however, a test may be made as described for E.O.T. cranes; see below.

The following items should be checked by the shop inspector:

(1) **Span** c. to c. of rails.
(2) **Tread of end-truck wheels** to fit runway rails specified.
(3) **End clearance,** see that maximum distance from centre of wheels to end of bridge conforms to clearance diagram.
(4) **Bottom clearance,** see that drop of bridge girders below rail is correct.
(5) **Top clearance**; measure end-trucks, girders and assembled trolley to see that the allowable height has not been exceeded.
(6) **Amount of hoist**; take measurements, with top of runway rail as a base, to see that the extreme position of hooks conforms to the drawing.
(7) **Check dimensions** for c. to c. of bridge girders and of end-truck wheels.
(8) Ascertain **main material** of bridge girders, web, flanges and stiffeners, making sketch of same.
(9) Ascertain and record **size of hoisting rope** or chain.
(10) **Examine hooks, blocks, wheels** and all other forgings or castings for cracks, twists, sponginess or other defects.
(11) Ascertain, as far as possible, that the **material supplied** is *complete.*
(12) Finally, see that all clauses of the specification and shipping instructions regarding **marking, painting, packing,** etc., are understood and are being complied with.

Inspecting Electric Overhead Traveling Cranes

This class of cranes is usually purchased under specifications calling for satisfactory fulfilment of a test before final payment is made; so that, except on large and important installations, shop inspection is an un-

necessary expense. For export work, however, when quotations can be obtained only for material f.a.s. shipping port, and when mistakes would be hard to ascertain and rectify in a distant country, shop inspection becomes essential. Specifications for export work should, therefore, contain a clause calling for assembly in the shop and the application of a test load, with trolley traverse under this load.

Inspection

Measurements for clearances, etc., should be made as scheduled for Hand Cranes (above), with cage and end-travel clearances also observed.

Test

This type of crane is usually required to be tested with a load 25 percent in excess of working load, all motions to be undergone. The steel bridge girders may be specified to carry a test load of 50 percent excess. The brakes should be tested at the 25 percent overload. Either the electrical or mechanical brake should sustain and lower the load, one being disconnected while the other is tested. The speeds of hoist, trolley traverse and bridge traverse at full and no loads should be measured to see that they come up to the specification.

The normal operating conditions, which the crane is specified to have to undergo, should be produced; and motors, brakes, etc., tested for any undue rise in temperature.

Structural Steel Inspection, Shop and Field[1]

The following "pointers" on this subject are addressed more particularly to the young graduate with no previous experience who is suddenly introduced to a bridge gang to inspect their work. They were prepared by one who had this experience, shortly after the close of a year of this kind of work. No pointers are given as to how to exercise tact and firmness; every man must learn these for himself.

General

The inspector should be furnished with a complete set of plans for the work in question, erection diagram as well as detail sheets. It is his duty to see that the work is fabricated precisely in accordance with the plans in every detail. It does not come within his province to check plans or determine quality of material, except in a very general way. Plans are not only supposed to be, but should be absolutely correct when they leave the drawing-room; at least there should be no errors which the templet shop will pass. Quality of material should have been determined at the rolling mill. Rivets are about the only thing he can test, by taking one and bending it 180° on itself, as shown in Fig. 101 (*a*). They should do this without showing any fracture or breaking of fibre or metal.

As stated briefly and concisely above, it is the Inspector's duty to see that every piece of steel checks with plans in every detail, such as:

Dimensions, especially noting out-to-out dimensions on milled pieces, distances from open holes to open holes, etc.

Size, whether 6 in. $\times$ 6 in. $\times$ 1/2 in. angle, etc.

[1] (By Carl F. Heintze.)

Thickness, of plates, lattice bars, connection plates, etc.
Number, size, spacing and kind of shop rivets.
Number, size, spacing and kind of open holes. (By kind is meant whether countersunk, full heads, etc.)
Note correctness of bent connection plates or bent braces of any kind.
Much bad field work is caused by inaccurate punching and bending of connection plates. Inaccurate punching causes use of drift pins or field reaming, and consequently bad and often loose rivets. Inaccurate bending of bent connection plates results in bad connections and loose rivets. The writer has seen skew portals on which it was impossible to secure a good connection or good rivets.
Marking of pieces should correspond with erection diagram.

Rivets

A good rivet (shown by full lines Fig. 101 (b), is one which entirely fills the hole, and in which there is sufficient stock to form upper head (formed by snap) as shown. The underhead must be tight up against the plate, as well as the upper head.

The under head is formed on rivet in the manufacture of the rivet. To test rivet proceed as follows: strike head on left side, which, if the rivet is loose, will

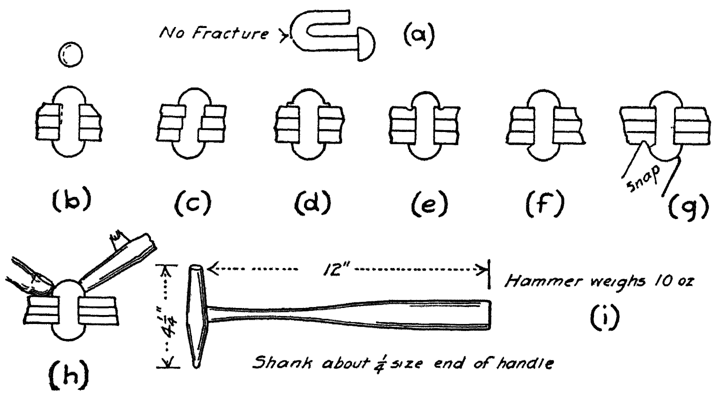


FIG. 101.—Illustrating rivet inspection.

drive it to the right side of the hole; then place thumb so that it touches both plate and rivet (as shown in Fig. 101 (h) in this case on left side), now strike rivet on right side, and if loose, you will feel movement with your thumb. After considerable practice one can tell by sound as well as by the sting in the hammer handle. A hammer which the writer has used with considerable success is shown in Fig. 101 (i); it weighs about 10 oz. One end has a dull point with which to punch rejected rivets. This marks the rivet and prevents plugging or use of other means of making a loose rivet a tight one.

A rivet to all outside appearances may be a perfectly good rivet and yet the metal will not entirely fill the hole. This is shown by the dotted lines in Fig. 101 (b), such a rivet will invariably be loose.

Fig. 101 (c) shows the result of inaccurate punching, somewhat exaggerated, perhaps, for purpose of illustration. It is very difficult to drive a perfectly tight rivet in this hole; the use of longer stock might help. If a drift pin is used, it is hardly possible to get heads in line. This may not be absolutely necessary, yet it is very desirable. If hole is reamed, it is hardly possible to

fill entire hole and rivet will undoubtedly be loose. A loose rivet is absolutely of no use in a connection and can never be of any use until every other rivet in the connection has failed.

Fig. 101 (d) shows a rivet having too much stock. This may not be a detriment but is unsightly and unnecessary; rivets having the proper amount of stock can be secured. It may result in loose rivets, due to the snap exerting its pressure on the superfluous lip and not sufficiently on the head of the rivet. The stock of the rivet will not be forced into the hole.

Fig. 101 (e) shows a rivet not having sufficient stock, this will invariably produce loose rivets. There is not head enough for the snap to exert its pressure against, and therefore it cannot force the rivet into the hole. This rivet can easily be detected by the depression made in plate by snap. This depression is certainly weakening the plate.

Fig. 101 (f) shows a rivet which is not up on the under side, due to the bucker-up not exerting sufficient pressure against this head of rivet. This rivet should be cut out.

Fig. 101 (g) shows what is known as plugging a rivet. The man driving rivets takes a rivet which is loose and using his snap as shown forces the plate under the head of the rivet. This practice should not be allowed, it is weakening to the plate.

It is well to remember that the more plates, the more difficult it is to get tight rivets.

In cutting out rivets judgment should be used, as in all things. One loose rivet in a connection having perhaps 50 or 60 rivets, can do no harm. In fact, more harm might be done by cutting out this loose rivet.

Inspection of Old Bridges

The following notes are extracted or abridged from Mr. W. C. Foster's "Treatise on Wooden Bridges," John Wiley & Co., 1913.

Wood

Test with small (1/2) in.) auger suspicious-looking places, filling afterward with a wooden plug or putty. Do not bore holes enough to weaken the timber. Or, drive a long, thin wire nail, and judge, by ease of driving, the soundness of the timber. Or, strike with a hammer and judge condition from sound.

Dig around piles for a foot or so to inspect, as this is the most vulnerable part.

In making inspection notes, first number all bents, stringers, floor beams, etc., according to some system, so that reference will be easy and definite. Make out a schedule (table) to take care of every member of the bridge, and show condition of each member thereon by some such system of symbols as

OK = good for more than 1 year.
D = dangerous, and must be removed at once.
6 = must be removed within 6 months.
S = must be removed within 1 year.
X = replaced since last report.

To test timber, use a 3/4 in. diameter × 5 ft. steel bar with ball one end and diamond-point at other; former for testing timbers above ground and apparently sound, and latter for prodding rotten portions.

Make sketch in field book and mark defective parts.

Examine stringer and cap bearings especially.

Masonry

Examine piers and abutments for settlement, bulging and cracks.
Pedestal stones for cracks, crushing, level, and bedding on bridge-seats.

Iron Bridges

Examine particularly.—
Pedestals, bed-plates, etc.
Tension members for equal strains.
Comp. members for straightness, and butting of joints.
Counters for tightness, and "full" nuts.
Hangers for cracks in bend, bearing on pin.
Nuts for tightness (a white streak painted across end will indicate any turning).
End-connections of stringers for loose rivets, etc.
Lateral rods for tightness.
Cast iron for cracks. A 1/4-in. hole at end of crack may stop it.
Test important rivets with hammer (see p. 326).
Drain-holes to be made and kept open.
Observe under train action for undue deflection, swaying or twisting.
Track on bridge and on approaches to be in good line and surface.

Inspection Reports

Inspection reports should be made out on some standardized plan or system, several copies typewritten, and variously filed under "Inspection Reports," "Contract Papers," etc.

Such a report should be headed with the name of the engineering or inspecting firm, and should give information under the following headings: (1) contract number and name, (2) material inspected; (3) specification and drawing numbers; (4) name and address of contractor; (5) name of inspector; (6) date of inspection; (7) scope of inspection; (8) quality of material; (9) quality of workmanship; (10) general remarks; (11) painting; (12) marking and (13) packing.

CHAPTER VIII

DOMESTIC SHIPPING

Introduction

In the shipping of machinery or other material from a manufacturing establishment to the site of an engineering development, certain forms have to be filled out, packing and directing operations properly observed, rules-of-the-road complied with, and final acceptance taken in due form; also there is, on the part of the railroad company, a great amount of routine to be observed and recorded.

The details of the work are often very complex, and the engineer unaccustomed to the routine, who may have occasion to take account of shipments, is usually bewildered by the formalities he encounters and annoyed by his lack of knowledge of such every-day matters of

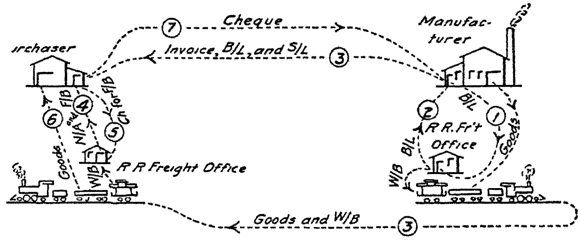


Fig. 102.—Diagram of procedure in domestic shipping.

business. Domestic shipping, in a country of the size and with such a variety of conditions as the United States, is a very complicated business, and all that will be attempted in the following pages will be to outline some of the steps and to give a few practical observations on the subject, for the information of the engineer who may not have become acquainted with its usages by actual experience.

Furthermore, "reminders" and detailed information as to packing, limitations of shipment, etc., will be given for the benefit of the designing engineer, whose work will often be controlled by these considerations.

For a list of abbreviations used by shippers, see p. 514.

Diagram of Procedure, Domestic Shipping

See Fig. 102; the numbers indicate the order of procedure.

The goods having been properly marked and weighed are taken to the freight office of the railroad, accompanied by a detailed ship-

ping list if the consignment is large and varied. A receipt for them is given in the shape of a Bill of Lading signed by the freight agent. Large shippers, however, usually make out the B/L themselves and it is simply signed by the agent. The agent makes out a Way-Bill describing and routing the shipment for the use of the freight conductor; on arrival of the goods at their destination, this W/B is turned over to the receiving freight agent, who then sends to the consignee a Freight Bill and Notice of Arrival.

In the meanwhile the manufacturer sends to the purchaser an invoice or bill for the goods, the bill of lading, and a copy of the shipping list (if any). The purchaser then presents the B/L to the agent at the receiving station, pays the freight bill (if not prepaid) and takes away the goods. After checking them against the S/L and being satisfied of their good order, a check in payment may be sent to the manufacturer and the transaction closed.

Such, in brief, is the usual procedure in making domestic shipments; variations of the transaction and descriptions of the forms used are given in the following pages.

FORM 22 9-1 09 5M M	a/77 TERMS: 30 Days Net No Cash Discount
WARREN, PA. 12/13/09	OUR ORDER NO. A-50790
Honolulu Iron Works #11 Broadway New York City	YOUR ORDER NO. V/O Mr.Brown L. 9/23/09
	SHIPPED TO Bush Terminal Co
BOUGHT OF	AT So. Brooklyn, N.Y.
STRUTHERS-WELLS COMPANY	BY Freight, prepaid
	CAR NO. P.R.R. 350360

1-Settling Tank, marked S.T. #3
Per contract, $918,00

MAKE ALL PAYMENTS TO ORDER OF STRUTHERS-WELLS COMPANY, ONLY

FIG. 103.—Example of a domestic invoice which is also a shipping list.

SHIPPING LISTS (DOMESTIC)

These are lists issued by the shipper or manufacturer giving details of a shipment. They are intended to aid the freight agent in making out his bill of lading and way bill, and to apprise the consignee of the details of the shipment. They are often demanded by the railroad company; and, in the case of a miscellaneous machinery shipment, etc., should be demanded (and in considerable detail) by the receiving engineer. However, in domestic shipping they are often extremely brief and general, and in many cases are not issued at all. An example of the usual brief domestic S/L is given in Fig. 103; a completely detailed S/L would be similar to the example of an export S/L given on p. 359 except that the dimensions of the packages would be omitted.

Invoice (Domestic)

An invoice is a bill from the seller for goods shipped to the buyer, with information concerning the size and character of the shipment given in more or less detail. If accompanying a packing or shipping list, the invoice may be merely a bill; on the other hand some shippers duplicate their shipping list and add the price so as to constitute an invoice. All styles of invoice between these extremes may be met with. An example of a simple form of invoice is given in Fig. 103.

Shipper's Receipts

These are receipts sometimes issued by the transportation company for partial lots of a single shipment. They are later exchanged for a single comprehensive bill of lading.

Bill of Lading (Domestic)

This is a receipt issued by the transportation company for the acceptance of certain goods, and is also a contract for their delivery at a place specified according to certain terms and conditions.

Bills of lading[1] are of two kinds, "straight" or "order." Both contain a statement of the number of packages shipped, description of the articles, their weight, rate, or class and rate, charges due and advances paid, name of shipper, shipping point, destination, route, car number and initials, and signature of the shipper and freight agent. Also they contain the usual conditions of contract, etc. The difference between the two lies in the fact that in the straight B/L the goods are consigned to the consignee, and that it is not negotiable; while in the "order" B/L the goods are consigned to the **order** of the **shipper,** and the freight is not delivered to a consignee except on presentation of the original order bill properly endorsed. More particularly, the "order" B/L (original copy only) is negotiable, and may be discounted by the shipper's bank when attached to a draft on the purchaser properly endorsed. The bank then sends the B/L and draft to its correspondent in the city to which the goods are billed. This bank, after collecting the amount of the draft from the purchaser, gives to him the original order B/L endorsed by the shipper, and this enables him to obtain his goods from the railroad company. There are also special B/L's, releases, etc., covering insurance, perishable goods, etc. It may be stated, however, that the first-described or "straight" B/L is the only one with which the engineer engaged on supply

[1] The following matter is, for the most part, extracted from Johnson and Huebner's "Railroad Traffic and Rates," D. Appleton & Co., N. Y., 1911

or construction work will usually be concerned. The "order" B/L is largely a merchant's instrument.

Form G F D 56) 12 09

Uniform Bill of Lading---Standard form of Straight Bill of Lading approved by the Interstate Commerce Commission by Order No. 787 of June 27, 1908

The Delaware. Lackawanna & Western Railroad Company.

STRAIGHT BILL OF LADING—ORIGINAL—NOT NEGOTIABLE.

Shipper's No. ____________

Agent's No ____________

RECEIVED, subject to the classifications and tariffs in effect on the date of issue of this Original Bill of Lading,

at ____ *19*

from ______________________________ the property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned and destined as indicated below, which said Company agrees to carry to its usual place of delivery at said destination, if on its road, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the conditions, whether printed or written, herein contained (including conditions on back hereof) and which are agreed to by the shipper and accepted for himself and his assigns.

The Rate of Freight from ______________________________

to ______________________________ *is in Cents per 100 Lbs.*

IF Times 1st	IF 1st Class	IF 2d Class	IF Rule 25	IF 3d Class	IF Rule 26	IF Rule 28	IF 4th Class	IF 5th Class	IF 6th Class	IF Special per ______	IF Special per ______

(Mail Address—Not for purposes of Delivery.)

Consigned to ______________________________

Destination, ______________________ State of ______________ County of ______________

Route, ______________________ Car Initial ______________ Car No ______________

NO. PACKAGES	DESCRIPTION OF ARTICLES AND SPECIAL MARKS	WEIGHT (Subject to Correction)	CLASS OR RATE	CHECK COLUMN	
					If charges are to be prepaid, write or stamp here, "To be Prepaid"
					Received $ ________ to apply in prepayment of the charges on the property described hereon.
					Agent or Cashier.
					Per ____________ (The signature here acknowledges only the amount prepaid)
					Charges Advanced. $ ________

______________________________ Shipper. ______________________________ Agent.

Per ______________________________ Per ______________________________

(This Bill of Lading is to be signed by the shipper and agent of the carrier issuing same)

FIG. 104.—Domestic (straight) bill of lading—original copy.

Bills of lading are *made out in triplicate*, consisting of an Original, a Shipping Order and a Memorandum—examples are given in Figs. 104, 105, and 106—the "body" of the forms is the same for all, the headings

and subscriptions only being different. The Original B/L is sent by the shipper to the consignee; the Shipping Order is retained by the R. R. agent; and the Memorandum is kept by the shipper for his records. Except in the case of small and simple shipments, *the B/L is made out by*

(Form G. F D 56) A 12-09

For use in connection with the standard form of Straight Bill of Lading approved by the Interstate Commerce Commission by Order No. 787 of June 27, 1908

The Delaware, Lackawanna & Western Railroad Company.

THIS SHIPPING ORDER must be legibly filled in, in Ink, in Indelible Pencil, or in Carbon, and retained by the Agent. Shipper's No.____ Agent's No.____

RECEIVE, subject to the classifications and tariffs in effect on the date of issue of this Shipping Order,

at____________________ 19

from________________the property described below, in apparent good order, except as noted

Charges Advanced:

$______

________________Shipper.

Per________________

☞ Agent must detach and retain this Shipping Order and must sign the Original Bill of Lading.

FIG. 105.—Bill of lading—shipping order copy (heading and subscription only; see Fig. 104).

the shipper and signed by the agent, and Fig. 107 illustrates a form of B/L (The S/O copy is actually shown, Auth.) adapted to the special requirements of a pump manufacturing concern.

Form G F D 56) B 12-09

For use in connection with the standard form of Straight Bill of Lading approved by the Interstate Commerce Commission by Order No. 787 of June 27, 1908

The Delaware, Lackawanna & Western Railroad Company.

THIS MEMORANDUM is an acknowledgment that a bill of lading has been issued and is not the Original Bill of Lading, nor a copy or duplicate, covering the property named herein, and is intended solely for filing or record. Shipper's No.____ Agent's No.____

RECEIVED, subject to the classifications and tariffs in effect on the date of the receipt by the carrier of the property described in the Original Bill of Lading.

at____________________ 19

from________________the property described below, in apparent good order, except as noted

Charges Advanced:

$______

________________Shipper ________________Agent.

Per________________ Per________________

FIG. 106.—Bill of lading—memorandum copy (heading and subscription only; see Fig. 104).

In some cases the *Original B/L* is returned to the R. R. Company on delivery of the goods, but more usually the "Arrival Notice and Freight Bill" (see p. 336), accompanied by a check for the freight charges, is returned to the R. R. Company to obtain the release of the goods.

For use in connection with the Standard form of Straight Bill of Lading approved by the Interstate Commerce Commission by Order No. 787 of June 27, 1906

D. L. & W. R. R. CO. Railroad Company

Shipper's Order No. P15717
Shipper's Branch No. D-1511-
Agent's No. G-9340

THIS SHIPPING ORDER must be legibly filled in, in Ink, in Indelible Pencil or in Carbon and retained by the Agent.

RECEIVE, subject to the classifications and tariffs in effect on the date of issue of this Shipping Order,

at HARRISON, N.J. 11,27,1909. 19 *From* GEO. F. BLAKE MFG. CO.

The property described below, in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned and destined as indicated below, which said Company agrees to carry to its usual place of delivery at said destination if on its road, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed, as to each carrier of all or any of said property over all or any portion of said route to destination, and as to each party at any time interested in all or any of said property, that every service to be performed hereunder shall be subject to all the conditions, whether printed or written, herein contained (INCLUDING CONDITIONS ON BACK HEREOF) and which are agreed to by the shipper and accepted for himself and his assigns.

The Rate of Freight from

to *is in Cents per 100 Lbs.*

IF . . Times 1st	IF 1st Class	IF 2nd Class	IF Rule 25	IF 3d Class	IF Rule 26	IF Rule 28	IF 4th Class	IF 5th Class	IF 6th Class	IF Special per	IF Special per

(Mail Address—Not for purposes of Delivery)

Consigned to BUSH TERMINAL CO. MARKS:- 45 48

Destination SOUTH BROOKLYN, N.Y. **State of** **County of**

Route **Car Initial** **Car No.** #4212

NO. PACKAGES	DESCRIPTION OF ARTICLES AND SPECIAL MARKS	WEIGHT (Subj. to Correction)	CLASS OR RATE	CHECK COLUMN
ONE	Steam Pumps (BOXED)			
	Boxes Parts, Steam Pumps			
	Pieces of Steam Pumps			
	Centrifugal Pump "FOR EXPORT"	980 LBS.		
	Cast Iron Water Meters			
	Boxes Cast Iron Water Meters			
	Air Compressor			
	Boxes Parts Air Compressor			
	Iron Valves			
	Mining Machinery			
	Pieces			
	Cases			
	Crates			
	Bundles			

HOBO. TFR.
N.Y.O.& W. 9647

If charges are to be prepaid, write or stamp here, "To be prepaid"

PREPAID

Received $ to apply in prepayment of the charges on the property described hereon.

Agent or Cashier

Per

(The signature here acknowledges only the amount prepaid.)

Charges Advanced

$

GEO. F. BLAKE MFG. CO. SHIPPER

PER

☞ Agent must detach and retain this Shipping Order and must sign the Original Bill of Lading

SHIPPING MANIFEST

N. B. PLEASE CHECK THE ARTICLES REPORTING ANY DISCREPANCIES AT ONCE

ORDER No.	PKGE	PCS	ARTICLES	GROSS	TARE	NET
CASE	#4212		ONE 7½X5X6 DUPLEX, PISTON PATTERN, BRASS FITTED, METAL VALVE PUMP #181683 WITH COMPLETE FITTINGS	980		820
			MEASUREMENTS	4/4	2/2	2/5

FIG. 107.—R. R. bill of lading (shipping order copy) of special form.

Way Bills

These are memorandums issued by the freight agent at the station of origin, giving details of the goods to be shipped, their car number, routing, freight charges paid and due, etc. They are given to the conductor to advise him of the routing of the goods, and no freight is moved without its way bill. The card tickets on the outside of the cars are made up from the way bills.

On arrival of the goods at their destination, the corresponding way bill is handed over to the receiving agent; it advises him of the freight charges to be collected, and later is used to apportion payment among the different carriers.

Lackawanna Railroad

NOTICE OF ARRIVAL OF FREIGHT

FORM A F & T A 17-V 2-11

Consignee Honolulu Iron Works Co. Produce Exchange, N. Y. 5/15/14 Pro. No. 16492

The Delaware, Lackawanna & Western R. R. Co.,

FROM	WAY-BILL No. AND DATE	CAR NUMBER	CAR INITIAL	CONSIGNOR
Balt	23944	7492	B & O.	Carnegie Steel Co.

ORIGINAL CAR NUMBER	ORIGINAL POINT SHIPMENT	ORIGINAL WAY BILL NUMBER
B. & O. 7492	Baltimore Md.	23944

ARTICLES AND MARKS	WEIGHT	RATE	FREIGHT	ADVANCES	TOTAL
25 Bdls Structural Steel	10000#	7¢	7.00	—	7.00

Make Checks payable to the order of **THE DELAWARE, LACKAWANNA & WESTERN R. R. CO.**
The above described property has arrived at HOBOKEN TERMINAL, N J, consigned to your address and is held subject to owner's risk from fire and other causes
If for export delivery, free time expires 7 — a. M. 5/25/14, if for domestic delivery .... M .... Your order endorsed on back of this notice must be presented to the undersigned. If inspection, sampling or repacking is required, notify
(Over) J E ELLIOTT, Agent Lighterage Dep't, Produce Exchange N. Y.

TOTAL 7.00
DRAYAGE

Fig. 108.—Railroad freight bill and notice of arrival.

Tracers

"Tracers" are letters or telegrams sent from the shipping point to various points on the route of shipment (usually junctions) to ascertain if the freight in question is going forward as desired. Tracers are only sent in case the goods have not arrived in reasonable time, or in cases where it is of particular importance that the shipment go forward with no delay. They are dispatched by the railroad company upon request, and without expense to the shipper.

In the ordinary course, "tracers" are made out on blank forms for mailing, but telegrams are sent when specially requested.

Freight Bill and Notice of Arrival

This is a notice and bill sent by the agent to the consignee when the goods have arrived at his station. An example of the form is given in Fig. 108. On the back of the notice are given standard warehousing regulations, etc., and space for endorsement by the consignee, together with (in the case of export shipments) instructions as to steamship and dock to which the materials are to be delivered. The notice, accompanied by a check for the freight bill, is then returned to the R. R. freight office, and the goods are released.

Demurrage

This is a penalty imposed on the consignee for not removing freight from cars in a reasonable time. Practice as to enforcement differs. "Free time" is usually 48 hours, with considerable latitude according to the time the car arrives. The usual demurrage rate is $1 per car per day; on L.C.L. shipments in the West and South, 5 cents per ton or fraction thereof per day. On material for export shipment, 10 days is the usual free time; but special arrangements are often made, and the time extended indefinitely.

Track Storage Charges

In addition to the above, in certain places (N. Y. City, for example) a charge is made on C.L. lots when track delivery is made. This amounts (in N. Y. City) to $1 per car per day on the third day after free time, $2 on fourth day, $3 on fifth, $4 on sixth, and $5 each succeeding day. This charge was originated to prevent cars being used as warehouses by certain consignees.

Carload (C.L.) and Less Carload (L.C.L.) Rules

Full-carload shipments are charged a much lower rate than less-than-carload shipments; this, of course, is largely because no re-sorting of the material is necessary en route, and because of the smaller amount of clerical and supervisory work connected with the delivery of the consignment. The L.C.L. rates are from about 50 to 125 percent higher than C.L. rates; the greatest difference occurring in the case of small, light articles requiring a large amount of handling in proportion to their weight.

When not otherwise specified (N.O.S.), the minimum weight which can take C.L. rates is 30,000 lb. The minimum C.L. weight specified is fixed so that the average car may be loaded to its capacity with the article in question. With the increase in size and capacities of freight cars, the tendency is to increase this minimum weight, especially in Western classifications, as large cars are becoming the rule in that section.

Freight Classifications, Rates and Rules

General Remarks.—The problem of assigning freight rates for different hauls, and classifying commodities for suitable charges, is one of extreme complexity in a country of such size, and embracing such varied interests as does the United States. Among the factors affecting the subject may be mentioned the relative cost of terminal movements, handling of less-than-carload matter, trunk-line operating expenses, class of material conveyed, profitableness of return hauls, and influence of competing lines. The following remarks are intended to be suggestive of the salient points of the business.

The **basis of rate-making for trunk line** movements may be illustrated as follows:[1] The base rate from Chicago to New York (920 miles) is taken at 25 cents per 100 lb.; from this deduct 6 cents per 100 lb. to cover terminal expenses at each end, leaving 19 cents for the "haulage charge." Then the rate for Indianapolis, 833 miles from N. Y., would be (833/920 $\times$ 19 cents) + 6 cents = 23.2 cents which is 93 percent of 25 cents the base rate. Therefore all Indianapolis rates will be 93 percent of the Chicago rates, and so for other places. The rate on first class traffic from N. Y. to Chicago by a standard rail line is 75 cents, by differential rail 69 cents and by ocean and rail 65 cents.

There are two general classes of rates in use, known respectively as **"Class Rates" and "Commodity Rates."** Commodity rates apply to standard materials which are continually being shipped and which the railroads have become accustomed to handling and know thoroughly the cost of transporting. A long list of these articles is given in the freight classification pamphlets. Any material presented which does not come specifically under one of these headings must take "class rates," a "classification list" being used to indicate the class under which the material falls. "Class rates" are somewhat higher than "commodity rates" for similar material. These classification lists are not the same throughout the U. S.; there are, at present, three in use for different territories; "Official" for N. and E., "Western" for west of the Mississippi, and "Southern" for the South.

When making a charge for a shipment, therefore, the agent first ascertains whether the articles are to be granted "commodity rates," and if not, he looks in the "classification book" to find what class the freight belongs to, and then in the "freight tariff" or "rate book" to get the charge for that class.

Extracts from Trans-continental Freight Bureau West Bound Tariff No. 1–L from Eastern Shipping Points to "California Terminals," Etc. (1910). Territory from which Rates Apply.—U. S. east of and including Col., Wyo., Tex., etc., divided into ten groups, A to J. Roughly "A" includes N.Y.C. piers; "B"

[1] Most of the following paragraphs are extracted or condensed from Johnson and Heubner's "Railroad Traffic and Rates." D. Appleton & Co., N. Y., 1911.

includes New England; "C" includes Eastern Canada, N. Y. (except as above) and the eastern states as far inland as Ky., Ind., Mich. (parts); "D" parts of Ill., Ind., Mich., Wis.; "E," "F," "G," "H," "I," and "J" parts of states increasingly farther west to Colo., Wyo., Texas and Okla., and N. M.

Export Traffic via Pacific Coast Ports.—Special rates and rules apply on "trans-Pacific" shipments.

Minimum charge, charge for 100 lb. at second class rate.

Charges on Packages Containing Articles of Different Classifications.—Charged at highest rate article rate. (A certain amount of machinery can usually be shipped with structural steel, however, at the rate for the latter. Auth.)

Freight consigned "to order" alone is not received.

Minimum carload weight is 30,000 lb. unless otherwise specified.

When car ordered by shipper is of less dimensions than carrier cares to furnish, the minimum carload tariff for the commodity will be charged, and not the minimum capacity of the car supplied by the carrier for its own convenience.

Excess Carloads.—When more than the minimum is shipped in one day by one consignor to one consignee on one B/L, the whole shall be charged at carload rates.

Maximum charge for L.C.L. will not be more than charge on basis of carload rate.

Articles in Boxes, Crates or Bales.—When Commodity Rates provide for articles "boxed" and do not provide for same in crates, bags, etc., they shall take when shipped in crates, or racks, 25 percent higher rate than in boxes, and when shipped in bales, bags or bundles, 50 percent higher rates.

Actual Gross Weight (including dunnage) charged for except as otherwise provided for.

Dunnage.—When articles in carloads require flat, gondola or other open cars, the weight of blocking, bolsters, straps, etc., for securing same will be added to the car tare.

"Value" or "Net Cost" used in connection with this tariff, means net cost to consignee at shipping point.

Shipments on open cars will be subject to a minimum charge (for each car used) equal to that for 5,000 lb. at first class rate.

Loading and Unloading Charges.—C. L. Shipments are not loaded and unloaded by carrier (at his expense) except as otherwise provided. L. C. L. Shipments—Rates include the expense of loading, and unloading, except A. O. S.

Live Stock, Coal, Coke, Grain, etc., are carried under special rates and rules.

Class Rates

On shipments for which no commodity rate is named herein, the following class rates, governed by Western Classification No. 48 (———) will apply:

To "California terminals"	In cents per 100 lb.									
	1st Class	2nd Class	3rd Class	4th Class	5th Class	Class A	Class B	Class C	Class D	Class E
Group A Rates..	300	260	220	190	165	160	125	100	100	95
Group J Rates.	300	260	200	175	160	140	120	95	85	80

Min. Charge.—See note above.
Rates for Groups B to I are intermediate between the above given limits (Auth.).

Commodity Rates, Examples of:

Below are given a few extracts (on machinery, etc., especially connected with engineering operations) from Eastern Shipping Points (designated by Groups) to "California Terminals." Rates are given only for Groups A and J, other rates are intermediate or similar. The list of articles on which commodity rates are provided is very extensive.

Table XI.—Examples of Commodity Rates from Eastern Shipping Points to "California Terminals" (1910)

Articles	Min. C L. weight	In cents per 100 lb. Group A rates L. C L	Group A rates C L.	Group J rates L C L	Group J rates C L.
Agricultural Implements, misc.	24,000	125	125	120	120
Asbestos Pipe Covering, etc.	24,000	150	100	150	100
Automobiles, Pass. and Freight	...	600	...	600	...
Brick, Fire.	40,000	...	50	...	50
Brick, Fire, boxed or crated	...	100	...	100	...
Cement in packages	40,000	100	55	100	55
Copper Pipe, Plates, etc.	...	185	135	185	135
Electrical Machy.					
Generator, Motors, Dir. conn. gen sets, Locos., Transformers, etc.	24,000	...	150	...	150
Parts for above, fittings, etc.	...	...	160	...	160
Wire and Conduit	...	...	125	...	125
Incandescent Lamps in barrels	16,000	300	200	300	200
Hardware, General	...	175	...	175	...
Houses, Portable, K. D., in bundles		185	125	185	125
Iron and Steel, Articles of.					
Angles, Channels, Beams, Columns, Girders, etc, not over 32 ft. long	...	130	...	130	...
Ditto (for each car used)	30,000	...	80	...	65
Boiler Plate and Sheet No 11 and heavier, flat	40,000	130	80	105	65
Do. No 11 to 16, flat	40,000	...	85	...	70
Boiler Heads, flanged.	...	150	100	150	100
Boiler, Steam, under 30 ft. in length.	24,000	...	150	...	150
Castings, N. O. S. as from mold, painted or dipped and bolt holes drilled but not machined, Heavy (each 100 lb. or over)	...	160	...	160	...
Ditto, light	...	...	80	...	80
Architectural-Iron or steel (other than sheet).	30,000	...	130	...	130
Pipe and Fittings, general	...	150	65	150	65
Pipe W. I, not over 12 in d.	40,000	150	65	150	65
Pipe N. O S, incl. Spiral Riv	24,000	150	100	120	80
Shafting, etc., not over 32 ft. lg. Hangers.	...	175	150	175	150
Sheet No. 12 and lighter, bl or galv. corr	40,000	130	95	105	75
Sheets punched for rivets, strapped	...	150	...	120	...
Tanks, N. O. S	24,000	...	150	...	150
Locomotives and Tenders, on Flat cars (Min for each car used)	30,000	...	150	...	150
Do. on their own wheels and narrow gauge loco. on Std. Trucks	60,000	...	...	...	95
Machinery and Machines·					
Gas and Gasoline Engines	...	...	140	...	140
Mining Machinery	24,000	...	150	...	140
Oil Well Supplies, misc	24,000	...	150	...	150
Rails, Steel, from Bethlehem, Pittsburg, Denver, etc., take special rates	...	...	...	...	...

Clearance Diagrams for Standard and Narrow-gauge Railroads

Figs. 109 to 113 give information concerning clearances on standard and narrow-gauge railroads. The data is intended primarily for the use of the designing engineer and draftsman when engaged in laying out big pieces regarding which there may be question as to the ability of the railroad to handle. In case the sizes approach the limits, however, it is essential that the traffic department of the railroad over which the mate-

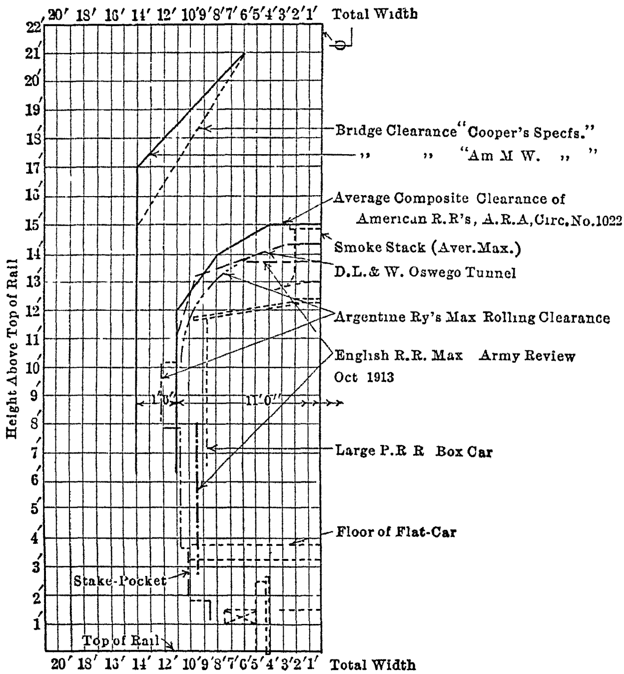


Fig. 109.—Clearance diagrams for standard (4 ft. 8 1/2 in.) gauge railroads.

rial will be shipped be consulted as to the allowable loading, as witness the limitations imposed on D. L. & W. shipments by the Oswego Tunnel clearance (Fig. 109).

Another use of the diagrams will occur in the design of doors for the passage of rolling-stock in industrial buildings, overhead structures in yards, etc.

The diagrams of clearances on the Argentine Railways are adapted from a paper by Mr. F. Lavis on "The Gauge of Railways, with Particular Reference to those of Southern South America," in the Proceedings of the American Society of Civil Engineers (Vol. 40; p. 587), presented April 1, 1914. When not otherwise credited, diagrams are by the courtesy of the railroad company designated.

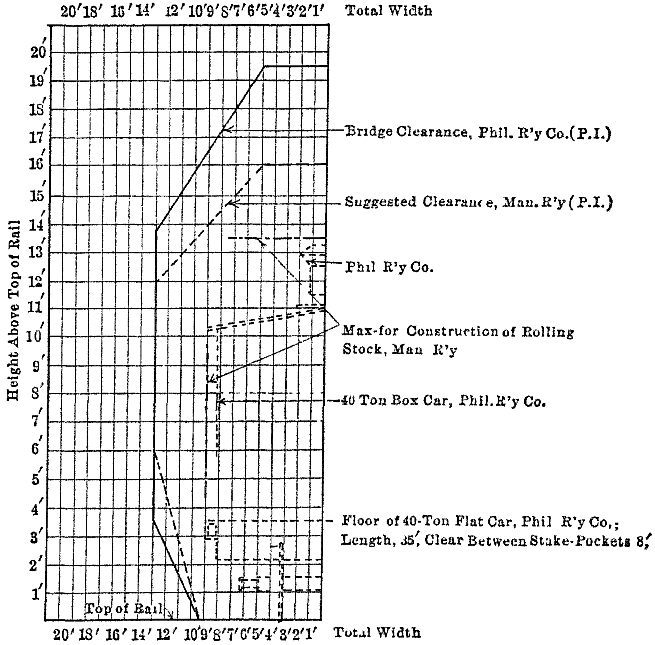


FIG. 110.—Clearance diagrams for 3 ft. 6 in. gauge railroads.

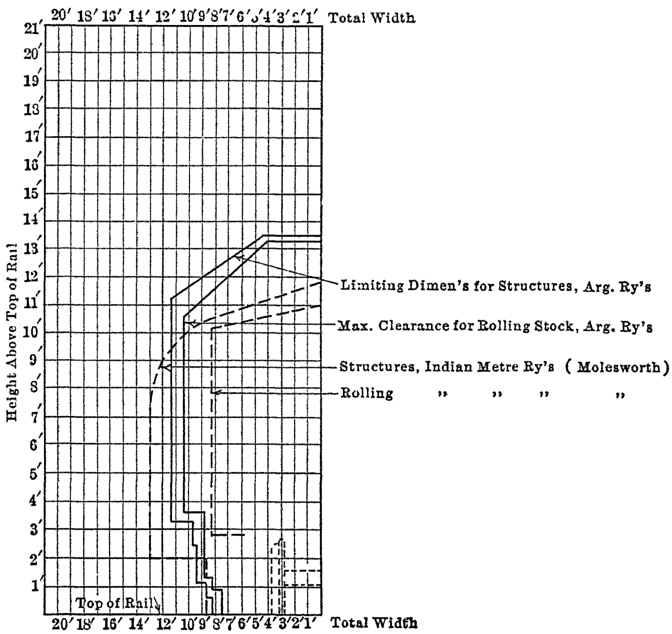


FIG. 111.—Clearance diagrams for Metre (3 ft. 3 1/3 in.) gauge railroads.

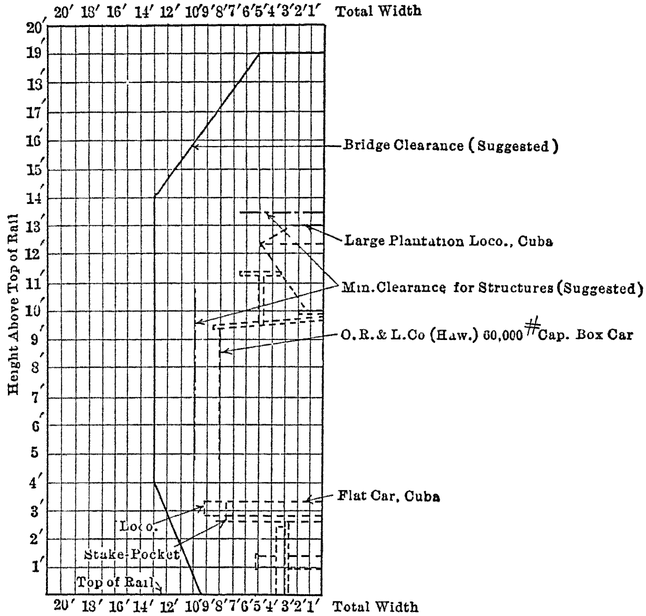


FIG. 112.—Clearance diagrams for 3 ft. 0 in. gauge railroads.

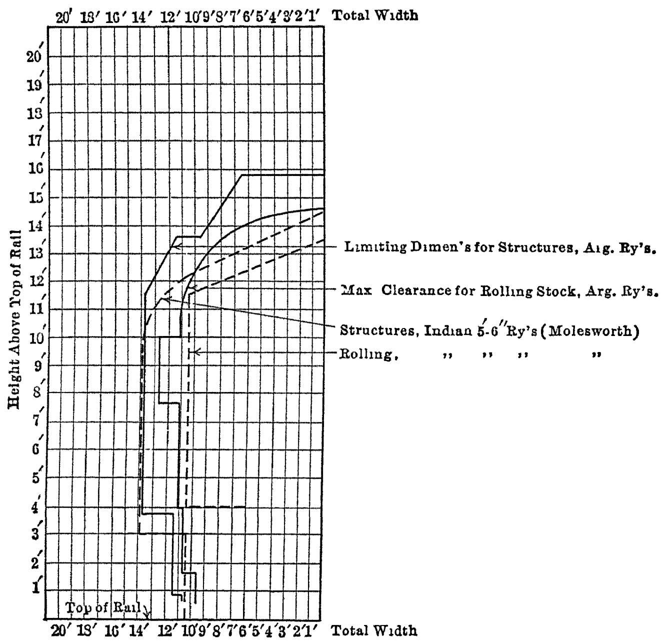


FIG. 113.—Clearance diagrams for 5 ft. 6 in. gauge railroads.

Packing for Domestic Shipment; Typical Examples

Methods of packing for shipment are governed by the following necessities, (1) of convenient handling, (2) to prevent pilfering en route, (3) to secure the material against damage due to usual handling or possible mishandling, (4) to secure the material against the jarring and other movements of the train, and (5) to protect against the weather.

The following notes on the usual methods of packing and shipping are intended as reminders and suggestions to engineers and inspectors who may be called upon to pass or criticize shipments from the works.

The **smallest machines** (engines, tools, etc.) should be completely boxed and well secured in the box.

Larger machines should be bolted to skids, so that they may be run on rollers, and the whole crated sufficiently to prevent danger of breakage if handled in slings or if thrown against other packages, etc., during shipment. All loose parts that could be unscrewed or otherwise readily removed by pilferers must be either safely secured, or packed in a box, which may itself, however, be secured within the crate. If intended for shipment in open cars, the machine must be properly protected from the weather by means of tarred paper, etc.

Large and heavy machinery is usually shipped in gondola or flat cars, properly secured against movement en route. Skids, securely bolted to the machine, should be provided if it is intended to move the material on rollers at any part of its travels. All journals should be protected with wooden strips wired on. All finished surfaces (and particularly wearing surfaces) which are in such a position as to be liable to injury, should have wooden protectors bolted on. Lighter parts on a heavy piece should be protected by boxing or crating.

It is sometimes possible to ship **large pieces** which would otherwise exceed clearance limits, by **cutting a hole in the floor of the flat car** so as to allow a part of the piece to be dropped through. This expedient is frequently used in the case of large gear-wheels, which are then shipped in a vertical position; or of other large bodies, which, if placed in a horizontal position on the floor of the car, would exceed the side-clearance limits.

Locomotives shipped on their own wheels should have their connecting-rods and side-rods taken off, and also the eccentric-rods and straps removed; all other "motion" may be left. The removed pieces and other material shipped loose may be placed in the cab, which may then be boarded up.

Small pumps shipped in one piece should be "skidded," and a boxing built around their valve motion.

When a **complete carload** of material such as pulleys, hangers, etc., pipe fittings or small machinery is to be shipped direct to the purchaser's

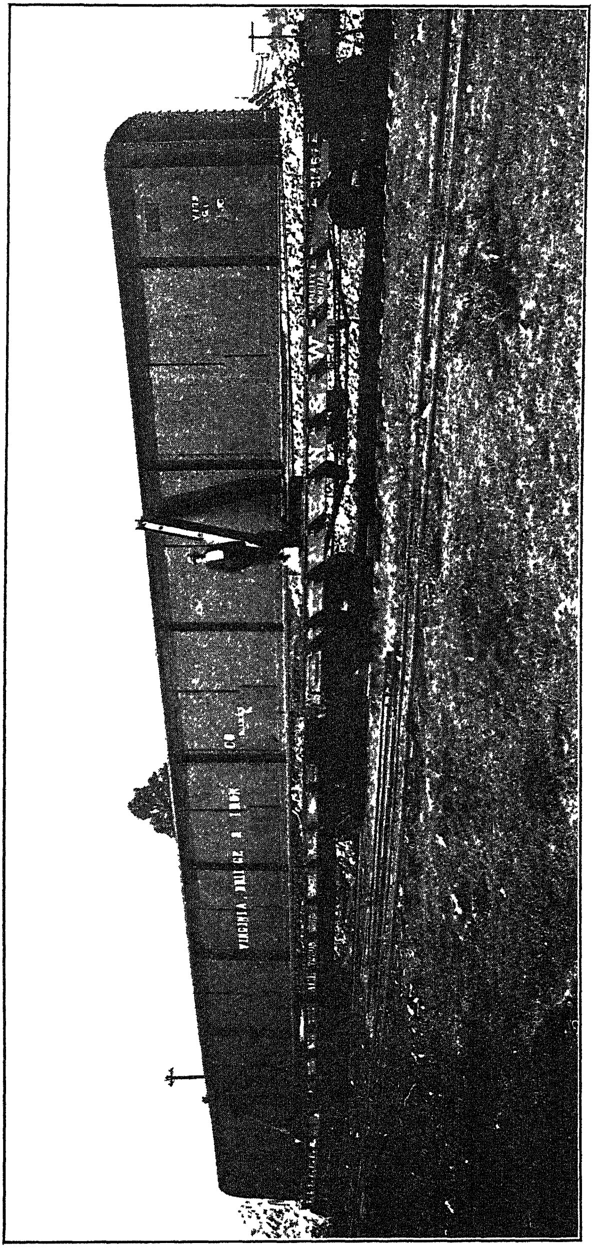


FIG. 115.—Single large plate girder secured to flat cars for shipment. (Courtesy of Virginia Bridge & Iron Co., Roanoke, Va.)

one or even two "spacers" between. In this case the carrying sills must be pivoted or attached to the car floor by means of a central pin, the sill itself moving on greased boards. The girder is held upright by wooden

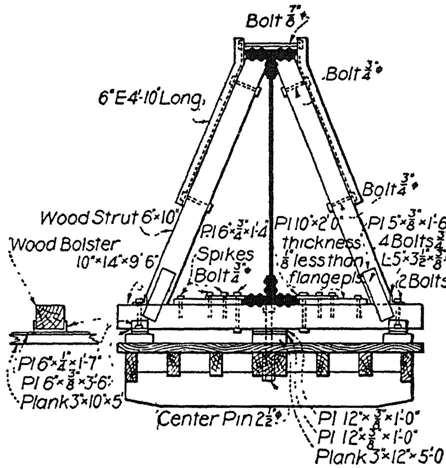


FIG. 116.—Method of supporting and bracing girders on cars.

struts or braces to the under side of its top-flange, the braces being strapped together around the top of the girder (see Fig. 115). Girders as long as 120 ft. have been shipped in this manner.

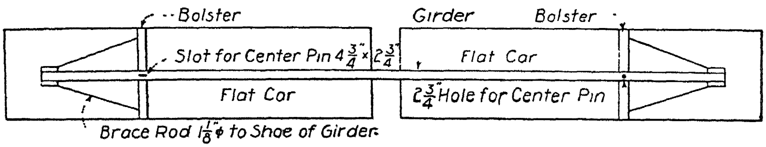


FIG. 117.—Plan showing end bracing of girder, and pivot pins.

The sizes and arrangement of bolster adopted by the Master Car Builders' Association is shown in Fig. 116, the dimensions being for girders weighing between 30,000 and 70,000 lb. A plan of the arrangement is shown in Fig. 117.[1]

[1] See "Eng. & Contr." Oct. 22, 1913, p. 460.

CHAPTER IX

EXPORT SHIPPING

Introduction

The brief description given in this chapter of the methods and formalities used in export shipping, is intended primarily for the information of engineers and managers who may be brought in contact with the subject unexpectedly or at irregular intervals of their usual work. The subject is very complicated, and is practised as a business by many large and influential firms, and by many men on the staffs of the larger contracting companies who do more or less export business. The engineer, then, will probably never be called upon to take any part in the routine of shipping methods; but if he is concerned in any way with the design or fabrication of an export job, it is essential, in order to secure safe and economical results, that he have a fairly comprehensive view of the whole scheme of operation, so that his work may accord with both the clerical and material requirements of the transaction. The engineer who takes a managerial position is rarely acquainted in any degree with the routine of export shipping; and, while the work may be placed in the hands of competent subordinates, a fair grasp of the whole subject will go far to give him confidence in the general procedure in connection with a complicated export shipment. Care has been taken to make statements and figures as nearly correct as possible, and to qualify remarks properly in the case of exceptions to general rules; the professional shipper, however, will probably notice many omissions and half-truths.

The following observations on export shipping, extracted from Ewing Matheson's "Aid Book to Engineering Enterprise"[1] will serve to illustrate the importance of a knowledge of the subject both to the designing engineer and to the financial agent.

Import duties will often influence very greatly the construction of exported machines or engineering material. Thus, bridge or building steel "unpunched or undrilled" is frequently assessed a lower duty than punched or drilled; and the final cost to the importer will often be much lower, even if the fabrication in his own country is expensive and poor, than it would be if the material were imported all ready for erection.

Where imposts are based on weight or quantity, it is poor policy for the importer to buy inferior material, as the duty is the same in either case but is a larger percentage of the cost in the case of the inferior material.

[1] Spon and Chamberlain.

Difficulties of inland transportation and of erection at site must be properly considered on the basis of actual conditions; it is not safe to infer always that foreign countries are deficient either in appliances or workmen.

Payment in foreign money is often subject to great and even ruinous changes. Payments to be made at extended intervals are especially risky and fluctuations should be provided for, either by stating that payment is to be made in New York or London funds, or that the rate of exchange is to be followed subject to revision if the difference passes a certain limit.

For a **list of abbreviations** used by shippers, see p. 514.

SEC. I. ROUTINE METHODS AND FORMS

Diagrams of Procedure; Export Shipping

Fig. 118 illustrates diagrammatically the sequence of procedure occurring in connection with a shipment of goods from the U. S. to a country requiring no consular or custom formalities, *i.e.*, to a free-trade country. Fig. 119 shows the additional procedures necessary when exporting to a country enforcing the typical consular and custom requirements. As explained on p. 368, the ordinances vary very much in different countries; also some countries require no consular formalities in the exporting country, but levy duty on the goods when received at their own ports.

The engineer's part in the procedure is usually as shown in Fig. 120.

Shipping to Countries having no Importation Formalities

(See Fig. 118)

The shipment from the manufacturer's works to the shipping-port is conducted as explained for Domestic Shipping in Chapter VIII, except that the shipping lists are made out in a more complete form, and that the goods are consigned to the care of the owner's agent at the port, to whom, also, all papers are sent. If the freight has been arranged for "lighterage free," the railroad company will deliver the material free of extra expense, either on lighters alongside the pier, or (if the pier has trackage facilities) in cars on the pier. The work of putting it on board the ship is done by the steamship company. If "free lighterage" is not included in the freight charge, the owner's agent must look after the transferring of the goods from the railroad company's depot to the steamship pier.

Sometime before the arrival of the goods at the pier, a "ship's permit" should be obtained from the steamship company who use this means of regulating the freight that may be accepted for each vessel. On arrival of each part of the shipment, the steamship company will issue "pier receipts" or "ship's receipts" for each batch. The owner's agent must

then "clear" the goods at the custom house (see p. 363), and present the certified "shipper's manifest" and the "pier receipt" to the steamship company, along with the amount of the freight bill. The steamship company will then issue a "bill of lading" covering the receipt of the goods and contracting for their transportation and delivery. On the eve of sailing the captain of the ship or his agent must take his "ship's manifests" to the custom house to get them certified or "cleared."

In the meantime the owner's agent will be obtaining marine insurance on the shipment; and will then forward by mail, to the owner or his agent in the country of importation, copies of the steamship bill of lading, shipping list, invoice and insurance certificate. The latter agent pre-

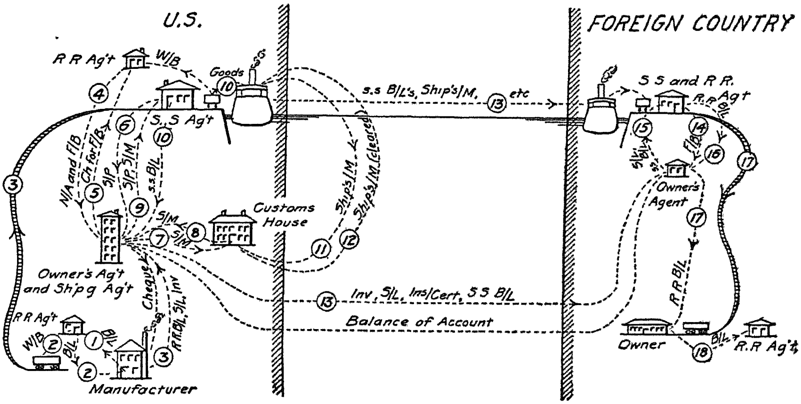


FIG. 118.—Diagram of procedure for an export shipment to a country having no importation formalities.

sents the bill of lading to the steamship company and receives the goods, checking them off by the shipping list; they are then forwarded to the owner in accordance with the railroad regulations of the country. The balancing of the account is usually done through the banks.

Additional Procedures When Shipping to Countries Requiring Consular and Customs Observances

(See Fig. 119)

The amount of formalities exacted varies very greatly, see explanation on p. 368; the example diagrammed is typical. The exchange of papers with the steamship company is usually the same as in the first instance, but more or less business must be transacted with the consul of the country to which the goods are going. "Consular invoices" and "certificates of origin" must be obtained and filled out, and taken to the consul for signature, and the required fees paid. The consul usually retains one copy of the papers for his file, and sends one each to the

custom house at the port of entry and to the chief of his bureau. The agent of the owner (the shipper) obtains as many more of these papers as he needs, usually sending two to the foreign agent. The goods are then "cleared" at the custom house and bills of lading obtained from the steamship company.

In clearing the ship's manifest, it is sometimes required that the papers be viséed by the consul, as well as by the custom house officers.

While the goods are in transit, the owner's agent sends by mail to the foreign agent copies of the "consular invoice" and "certificate of origin" (often combined), bills of lading and the insurance certificate. These are usually turned over to a custom house broker, at the port of entry, and he attends to all formalities of passing the goods through the custom house and releasing them from the warehouse.

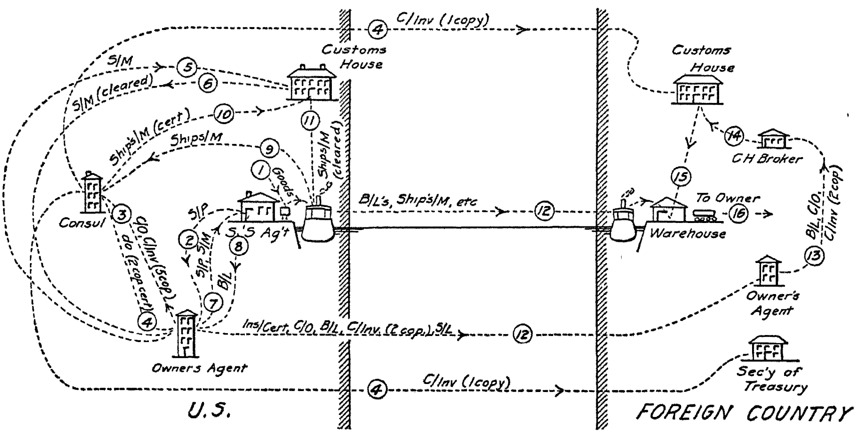


FIG. 119.—Diagram of additional procedure required for an export shipment to a country requiring consular and customs observances.

FUNCTIONS OF THE ENGINEER IN EXPORT SHIPPING

(See Fig. 120)

These will consist usually in inspecting the material, checking the shipping list, and certifying the invoice.

The duties of inspectors engaged on the passing of partly worked-up and finished material are outlined in Chapter VII; but attention must also be paid to the packing of the material, notes concerning which are given on p. 376, and to the marking (see p. 354).

In many cases the shipping lists received from the manufacturer are never compared with the order to see that all the material is going forward. Some of the troubles that may and do arise from lack of this procedure are described on p. 358. As there explained, the necessity for a thorough checking of the shipping list against the specifications, lists, and

drawings, is particularly necessary on export shipment; and a conscientious certification of the invoice demands that it be done.

In some cases it is of great advantage to have the material checked off the shipping list when going into the ship by a member of the engineering staff who is thoroughly familiar with the installation being exported. The omission, breakage, or wrongful supply of some part of a machine will often be detected by such an observer; and the obviation of future trouble may pay the extra cost of using such a man for this work many times over.

Custom House Brokers

The formalities to be observed in exporting and importing goods are often very complex. Custom house brokers are firms or individuals who, for a small fee, will attend to all the details in connection with the drawing-up and presentation of the necessary papers, etc., and thus save the shipper or importer the expense of keeping a special staff of employees for this purpose. The larger firms of forwarding agents sometimes attend to the matter themselves, but in general it may be said that it is far cheaper and more satisfactory to employ a broker to do the work.

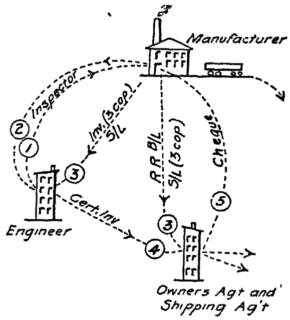


Fig. 120.—The engineer's place in the diagram.

On export shipments, where the office-force is familiar with the steamship company's and the consular requirements, the clearing of the shipment at the custom house may be done by a clerk, as the additional amount of work is very small; but where export shipments are only occasionally made, it is better to turn over the invoice, railroad bills of lading, etc., to a broker who will attend to *all* the shipping formalities.

On import shipments it is practically impossible for the occasional receiver to attend to the business of getting the goods through the custom house himself; the papers should always be placed in the hands of a broker.

Following-up Orders for Export Shipment

Any delay in placing material alongside a steamer for export shipment is often a serious matter. Exporters, therefore, usually employ some form of "follow-up" system to control the progress of the material coming forward for shipment. This usually takes the form of a return post card sent to the manufacturer inquiring as to the progress of the work. The reverse side of a card of this sort is shown in Fig. 121. The issue of these cards at proper intervals can be automatically controlled by some such system as is described on p. 225.

The same methods can, of course, be advantageously applied to domestic shipments, especially in the case of installations requiring to be rushed through for completion at a specified date.

New York,. .. 191...

Gentlemen:

Kindly advise the present standing of our order No. . .. for mark........ ..and state when same will be ready for shipment, using the attached return card for your reply.

MELCHIOR, ARMSTRONG & DESSAU

116 BROAD STREET,
NEW YORK

.. . . .191 ..

Gentlemen:

Your order No... .. .. for mark............ ....will be ready for shipment about.. .. ..

....

....

. .. .

. . . .

FIG. 121.—"Follow-up" return post card for ensuring shipment on time.

SHIPPING INSTRUCTIONS (EXPORT)

Below is an outline for uniform shipping instructions such as should be sent out by a firm of exporters in order to obtain completeness and uniformity of procedure in single or consolidated shipments.

Many manufacturers in the U. S. have much to learn regarding export shipping, and very strong representations have sometimes to be made to them to secure compliance with the requirements of the steamship companies and the foreign consular agents. As much attention should be given to the shipping instructions on an export shipment as to the clauses of the specifications for the material itself.

The clauses relating to packing, painting and numbering packages, and preparation of shipping lists, should also be outlined in the specifications, so that the bidder may be made acquainted beforehand with these (extra) requirements.

BLANK TRADING COMPANY

NO. 1 NORTH ST., NEW YORK CITY, U. S. A.

Export Shipping Instructions

Date——————————19——

Our Cont. No.——————Name——————————————

Our order No.——————Material——————————————

For delivery at——————————————by——————19——

Mark

Packing.—This material will be shipped to——————————————
under conditions outlined below, and must be packed accordingly.
Conditions:——————————————
(Author's Note.—State whether conditions are "Usual," or outline any such special features as are described on p. 374.)
Any expense we have to assume for re-packing or reinforcing boxes or crates at the order of the steamship company will be charged to the manufacturers from whom the shipment originated.

Painting Packages.—All loose material is to be painted a——————color, and all boxes, crates, etc., are to be painted——————on one side and one end for purposes of identification. (Author's Note.—This requirement is unusual, only necessary when packages are sorted by semi-civilized labor; in such cases it is a very useful device.)

Package Numbers.—Each package is to bear a separate number, in——————paint, in two places, numbers to be stenciled if possible, in conspicuous locations, but one of the marks at least to be placed in a protected position so that it will not rub off in transit. Numbers are to be—————— and up. (Author's Note.—Sometimes numbers are assigned, such as 300 to 500, but on a large consignment it is sometimes difficult to apportion numbers properly among the different shippers. A better method, therefore, is to have the package number appear immediately beneath the shipping mark, which usually shows the order number; each shipper may then number from "1" up.)

Shipping Mark.—All packages are to bear the mark in ———— paint in *two* conspicuous places, as described for "package numbers"

Dimension and Weight Marks on Packages.—Every package is to be marked with its three "right-angle" dimensions in feet and inches (not cubic-foot contents). Note that skids, etc., must be counted in in these dimensions.
Also give the equivalent dimensions in millimeters. (Author's Note.—This is special, and may be struck out of some instructions.) Every package is to be marked with its "net" and "gross" weight in pounds (and kilograms).
All the above markings to be made in ———— paint.

Shipping Lists.—Shipping lists are to be **complete,** indicating (1) number of each package, (2) whether piece, box, crate or barrel (do not use the term "case"), (3) measurement in feet and inches (not cubic contents only), (4) gross and net weight, (5) detailed contents of each package, (6) total number of packages, and (7) total net and gross weights.

At the head of each list is to appear the date of shipment, our order number, mark, car number, and consignee, as well as your firm name and address. We shall require ————————(——) copies of the shipping list.

Consigning.—Consign all material to————————————————————————————————, notify————————————————————.

Routing.—If possible, give a New York delivery routing in addition to the initial routing so that material may not arrive in New York by different railroads. Special Notes. ————————————————————————————————————

Prepaying Freight.—All material purchased f.o.b. New York or f.a.s. N. Y. Harbor should have the freight prepaid, otherwise we shall withhold payment of invoice until material arrives at terminal and proper deduction can be ascertained. State on R. R. B/L in a prominent manner that freight has been prepaid.

Railroad Bill of Lading.—Send us the original and ————————(———) copies of the R. R. B/L. Be sure to mark on B/L, "For Export."

Dock Receipts.—If delivery is made direct to steamer dock, you will furnish us immediately with proper dock receipt.

Invoices. Send us ————————(——) copies of invoice.

The Blank Trading Co.,
Per———

Marking Packages for Export Shipment

An example of a simple case of marking is given by Fig. 122. This was used on material shipped from the U. S. to the Philippine Islands.

S.C.M. CO.	3 ft. 6 in. × 4 ft. 8 in. × 12 ft. 3 in.
474-SUP	2,160 lb. net
San Carlos	2,510 lb. gross
No. 26	

Fig. 122.—Example of simple marking of export package.

The first letters are the abbreviation of the name of the owners; the number "474-SUP" indicates that the material is furnished under Order No. 474, for supplies; the name "San Carlos" is the place of final delivery; the number "26" is the "package number," there being in all (say) thirty-two packages under this order number; the other figures give the dimensions and weight of the package for the steamship company to check, and on which to make up their freight bills, etc.

In case the goods are to be shipped to a country in which the metric system is in force, it is usually necessary to give dimensions and weights in that system also; Fig. 123 is an example of such a marking.

This package was destined for the Cambrian Sugar Co. (the consignees), doing business in Brazil. Their N. Y. agents were Brown, Jones & Co., who attended to all papers, etc., incidental to shipping the goods.

In some cases it is necessary to mark on the package, also, the "*Legal Weight*" or weight of material on which duty is to be paid. In the case of a box of hand-hammers, for example, the "gross weight" would include the packing-case, wadding, etc.; the "net weight" would include the cardboard boxes and paper in which each dozen was packed; while the "legal weight" would include only the "naked" hammers, or, in certain cases, the weight of the hammer-heads alone, on which duty was to be paid.

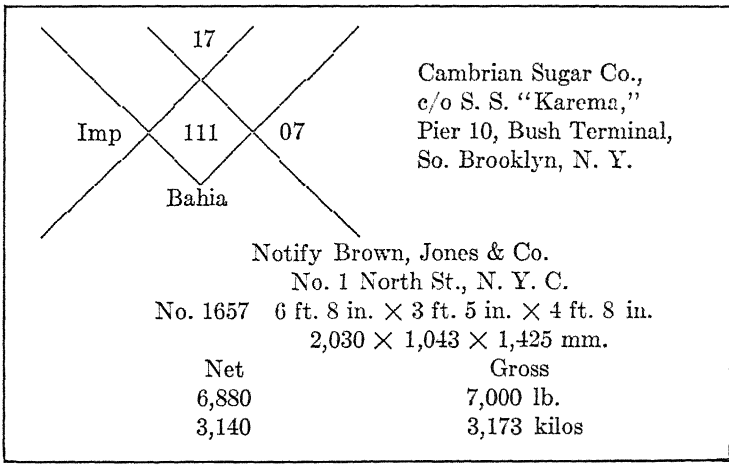


FIG. 123.—Example of more complicated marking.

LIGHTERAGE

In the larger ports of this country it often happens that a railroad company will not have direct track communication with many of the piers. Goods destined for such piers must therefore often be sent over in lighters from the railroad company's pier, or, in case of carload shipments, must be sent on car floats. On certain classes of goods the railroad companies make no direct extra charge for this service, and the material is said to be granted "free lighterage" or to be delivered "lighterage free"; in other cases, extra charges are made.

New York Harbor handles more freight in this way than any other port in the country, and in order to regulate this traffic, each railroad doing terminal business at that port issues a bulletin of rules for the guidance of its freight agents. The following notes are extracted from the regulations of the Erie R. R. Co., and may be taken as typical.

Definition of the Term "Lighterage Free"

This should be understood to mean that carload shipments of articles entitled to free lighterage will be lightered free to or from any steamship pier or public landing within the free lighterage limits of New York Harbor. In other words, the freight rate to or from New York Harbor from or to other railroad points, on carload shipments of allowed articles, includes the cost of lighterage in New York Harbor. The cost of unloading and putting in the vessel is, of course, at the expense of the steamship company.

Articles not Entitled to Free Lighterage

Machinery, etc., in general, is entitled to "f.l." except that heavy lifts pay extra (see below). Articles that require shoveling or much handling, such as coal or coke in bulk, loose bricks, etc., or oils, acids or explosives, are *not* entitled to free lighterage. Furthermore, "f.l." is accorded to carload shipments only (or to carloads + fractions under same B/L), unless otherwise provided.

Lighterage of L.C.L. Freight which in C.L. is "L.F."

This is charged at the rate of 3 cents per 100 lb. with minimum of $9 for each L.C.L. domestic shipment, and minimum of $6 for each L.C.L. export shipment; over and above rate to and from rail terminal.

Miscellaneous Lighterage Regulations

For deliveries of street cars, empty tank cars, launches or other boats over 25 ft. in length, extra charges of from $10 to $60 are charged.

For "heavy lifts," pieces up to 3 tons are free, pieces over 3 tons are charged extra per ton at a rate increasing with the weight, but for large shipments these extra charges are waived to some extent.

Demurrage is charged at a rate depending on the size and class of float detained.

L.C.L. export freight handled by the railroad company's draymen is charged extra according to the location of delivery pier.

Export Freight Rates

For steamship shipments, the extreme divisions of freight classification with corresponding rates that are used in railroad shipping are not adopted. But, on the other hand, the use of the "cubic-foot" rule and the extra charges for "heavy lifts" complicates the matter of freight-rate adjustment even more than in the case with the railroads. This is so much so that, in the case of a miscellaneous shipment of heavy and bulky machinery, it is practically impossible to figure what the freight charge will be from the gross weight alone, and it is necessary either that the weight and dimensions of each package be known, or that figures be at hand showing previous charges on similar shipments.

The rule as to measurement is that **"40 cu. ft. equals 1 ton;"** or 1 "Cubic Ton" contains 40 cu. ft. This means in practice that if, for example, a package weighs 2,000 lb. but measures 50 cu. ft., it is liable to be charged at the "per cu. ft." rate, because it is so bulky that its ton of weight occupies more space than 40 cu. ft. This cubic-foot measure-

ment does not mean the displacement of the exterior surface, but is the product of the maximum dimensions in three right-angle directions. Thus a tank or hotwell 6 ft. diameter × 18 ft. long is not counted as having a volume of 510 cu. ft. (obtained by multiplying its end area by its length), but of 648 cu. ft. (the product of 6 ft. × 6 ft. × 18 ft.). If this tank weighed 7,000 lb. and the rate for this weight to the port in question was $.70 per 100 lb. the freight charge would be $49 and if the rate per cubic foot was $.14, the alternate charge would be $90.60; the steamship company would then charge the cubic-foot rate.

For pieces of machinery weighing over 2,000 lb. each, the rate per 100 lb. **increases very materially.** The table given below illustrates this increase, and also shows the usual divisions of weight adopted in fixing the rate; summaries of shipping-lists should be divided according to the same schedule (see p. 477).

Table XII.—Comparative Freight Tariff, New York Harbor to Cuba

Brick	per 100 lb.	.18
Cement (400-lb. bbl.)	each	.53
Cement (bags)	per 100 lb.	.15½
Clay, bags or bbl.	per 100 lb.	.23
Iron Bars, Sheets, etc.	per 100 lb.	.24
Iron Bolts, Spikes, etc.	per 100 lb.	.24
Iron Pipe and Fittings, 12 in. and under	per 100 lb.	.24
Iron Pipe and Fittings, over 12 in.	per 100 lb.	.35
Iron Pipe Riveted, 12 in. and under	per 100 lb.	.45
Iron Pipe Riveted, over 12 in.	per 100 lb.	.60
Iron Corr. Sheets	per 100 lb.	.24
Iron Beams and Structural	....	...
Not over 30 ft. long to 4,000 lb.	per 100 lb.	24
At ship's option	per cu. ft.	.10
Over 30 ft. long, See "Machinery"	....	...
Lumber (White Pine, ordinary)	per M.	4 80
White Pine, dressed	per M.	6 00
Hardwood	per M.	7 50
Pitch pine	per M.	7.50
Lime (slacked)	per 100 lb.	.18
Machinery, under 2,000 lb.	per 100 lb.	.29
2/4	per 100 lb.	.34
4/6	per 100 lb.	.46
6/8	per 100 lb.	.69
8/12	per 100 lb.	.86
12/20	per 100 lb.	1 15
over 20,000 lb.	special	....
Meas. rate at Ship's option	per cu. ft.	.14
Rail and Fastenings	per gr. ton	4 00
Portable Track	per 100 lb.	.35
Minimum B/L	....	5 00
Goods N O.S. (not otherwise specified)		
Measurement	per cu. ft.	.14
Weight	per 100 lb.	.35

In the above example the ton of 2,000 lb. is cited; this is the weight of the ton used by American shippers, but **English firms count a ton as 2,240 lb.** with the same equivalent of "40 cu. ft. equals one ton" for measurement purposes.

The table given on page 357 is extracted from an old freight tariff from New York Harbor to a Cuban port; it will serve to indicate the usual classifications and their relative freight rates.

In addition to the freight rate, a "primage" of about 5 percent of the freight bill is often added. This was intended formerly to cover the cost of the ship-master's care of the goods, but it is now usually included in the freight charge.

Shipping Lists (Export)

These are lists issued by the shipper or manufacturer giving details of a shipment. They are also known as Packing Lists, Shipping Manifests, Manifests, etc. Unlike domestic shipping lists, they must be made out in considerable detail. This is because the steamship company, in the first place, requires the dimensions, weight and description of package of each piece so that they can assign the proper freight rate; and also because, the material being usually boxed, it is necessary that the consignee have information as to just what is in each package, so that (for example) he would not have to open every package to find any particular piece of machinery he required. They should therefore contain information as to the domestic shipment and delivery, general mark, number and kind of package, dimensions, net and gross weight, and a complete list of the material in each package, and finally, totals of the above figures.

Examples of export shipping lists are given by Figs. 124 and 125. The blank forms are often furnished by the exporting firm to the manufacturer, so that the records of the former may be uniform, and as complete as desired.

Checking Shipping Lists

This procedure applies more particularly to Export Shipping Lists, those for domestic movements are usually so brief and general that inspection would serve no particular end.

The critical examination of shipping lists for structures or machinery for export, however, is often a matter of vital importance. The author has had personal acquaintance of a case where, on checking the shipping list for an order of large steam pipe and fittings for a sugar factory for an isolated part of Mexico, a large amount of material was found to be missing. Inquiry disclosed the fact that two or three sheets of the contractor's order list had been misplaced and that the corresponding amount of material was omitted from the shipment. Had this not been caught in

Export Packing List Sheet No. A177

HONOLULU IRON WORKS CO.

A–50790 NEW YORK CITY

Shipped Via P. R. R. *Car No.* P. R. R. 350360

Consigned to Bush Terminal Co., South Brooklyn, N.Y. *Order No.*———

Marks: 45———48 Notify Honolulu Iron Works Co.

No. 2810 to 2815 inc.

Takav. *Date* 12/13/09.

Package number	Kind of package	Cubic measurement	Weight		Contents and remarks
			Net	Gross	
	One (1)	Settling Tank 7′ 0″ × 13′16″ × 6′ 3 $\frac{9}{16}$″ deep on one side and 6′ 6″ deep. Marked S. T. 3 and Packed for export shipment as follows:			
2810–	1-Bdl.	13′6″×6′3″×1″	1,870	1,870	2–Side plates.
2810$\frac{1}{2}$–	1-Pc.	13′5″×7′2″×6″	1,215	1,215	1–Bottom plate.
2811–	1-Bdl.	7′1″×6′7″×7″	1,000	1,000	2–End and Partition plates.
2811$\frac{1}{2}$–	1-Bdl.	7′1″×6′7″×7″	990	990	2–Plates.
2812–	1-Bdl.	14′1″×4″×4″	280	280	6–2$\frac{1}{4}$″×2$\frac{1}{2}$″×$\frac{1}{4}$″ angles.
2812$\frac{1}{2}$–	1-Box	1′2″×1′6″×9″	106	130	10–(3 lb.) $\frac{5}{8}$″×2″ rivets.
					40–(10 lb.) $\frac{5}{8}$″×1$\frac{1}{2}$″ rivets.
					875–(90 lb.) $\frac{1}{2}$″×1″ rivets.
					20–$\frac{1}{2}$″×1$\frac{3}{8}$″ rivets.
2813–	1-Box	5′2″×1′9″×1′2″	375	465	54–2$\frac{1}{2}$″ × 1$\frac{1}{2}$″ × $\frac{1}{4}$″ × 4′ angles and clips.
					4–Gusset plates.
					6–6 × 12 × $\frac{1}{4}$″ × Sketch plates.
					3–4$\frac{5}{8}$″ × 4″ × 2$\frac{3}{8}$″ plug valves.
					3–4″ dia. mud elbows.
					3–4″ dia. Clear juice elbows.
					9–9″ dia.×$\frac{1}{16}$″ gaskets.
					12–$\frac{3}{4}$″×2$\frac{1}{4}$″ Bolts and nuts.
					24–$\frac{3}{4}$″×3$\frac{1}{4}$″ Bolts and nuts.
					54–Carriage bolts and nuts.
					140–No. 14×2$\frac{1}{2}$″ B.H. Wood screws.
					3–Copper floats.
					3–Brass float supports.
					6–$\frac{1}{2}$″×2″ brass bolts with nuts.
2813$\frac{1}{2}$–	1-Box	7′3″×1′6″×1′3″	138	240	3–Brass pipes complete with elbows, discs, and cap screws.
					3–$\frac{5}{8}$″×92″ valve stem rods.
2814–	1-Box	3′3″×2′5″×1′0″	378	443	3–4″ Gate valves and levers.
					3–4$\frac{1}{8}$″ Brass body connections.
2814$\frac{1}{2}$–	1-Bdl.	4′5″×1′5″×8″	125	125	12–$\frac{7}{8}$″ diameter braces.
2815–	1-Bdl.	12′2″×3″×2″	125	125	6–Bars 1$\frac{1}{2}$″×$\frac{1}{8}$″×12′ lg.
					6–Bars 1$\frac{1}{2}$″×$\frac{1}{8}$″×10′ lg.
Total	4-Boxes 6-Bdls. 1-Pc.			6859lb.	

FIG. 124.—Example of export shipping list. (Size of sheet, 8$\frac{3}{4}$″ wide × 15$\frac{1}{2}$″ deep.)

SHIPPING MANIFEST

BRANCH OFFICE NO. FD-1488-B SHOP ORDER NO. G-9080/90

THE GEO. F. BLAKE MFG. CO.

CUSTOMER'S NO. Formosa NO. PAGES 3 PAGE NO. 2

SHIPMENT OF Contract D-6489 EAST CAMBRIDGE, MASS., 11/24/09. 190

CHARGED TO Honolulu Iron Works,
11 Broadway, New York City.

SHIPPED TO Bush Terminal Company,
South Brooklyn, N. Y.

ADDRESS For Export, Notify Honolulu Iron Works,
11 Broadway, New York City.

VIA B. & A. N. Y. C.

PART
COMPLETE FACTORY
COMPLETE O. D S.
COMPLETE
Complete.

N. Y. C. CAR NO. 59915
N. Y. & ST. L. 11014
Freight Prepaid

BILL OF LADING TO

TRACK WEIGHT GROSS TARE NET

N. B. PLEASE CHECK THE ARTICLES, REPORTING ANY DISCREPANCIES AT ONCE

Order No	Package No	Pieces	Articles	Gross	Tare	Net
			L B D			
G-9086			Three (3) $6 \times 5\frac{1}{2} \times 7$ single filtered juice re-melted sugar pump.			
	4162	1	Case 5′1″ 1′4″ 2′0″	677		529
			Pump No. 182241			
	4163	1	Case 5′1″ 1′4″ 2′0″	665		527
			Pump No. 184859			
	4164	1	Case 5′1″ 1′4″ 2′0″	670		532
			Pump No. 184860			
G-9087			Two (2) $8 \times 7 \times 12$ single molasses pumps			
	4165	1	Case 6′8″ 1′5″ 2′9″	1,178		937
			Pump No. 180997			
	4166	1	Case 6′8″ 1′5″ 2′9″	1,190		947
			Pump No. 181050			
G-9088			Two (2) $6 \times 6 \times 12$ single Alkaline water pumps.			
	4167	1	Case 6′8″ 1′5″ 2′7″	1,080		874
			Pump No. 182798			
	4168	1	Case 6′8″ 1′5″ 2′7″	1,087		849
			Pump No. 184480			
G-9089			One (1) $4\frac{1}{2} \times 3\frac{3}{4} \times 4$ duplex wash water for filter presses pump.			
	4169	1	Case 3′5″ 1′4″ 1′10″	412		322
			Pump No. 181454			
			Note.—This pump is shipped from Harrison works. It is not in these cars.			
G-9090	4170	1	Case 5′11″ 1′8″ 2′7″	1,095		885
			One (1) $8 \times 12 \times 12$ single air compressor No. 184781.			

FIG. 125.—Example of export shipping list.

the engineer's office, the loss to the sugar plantation consequent on the partial loss of the crop would have amounted to hundreds of thousands of dollars and the ruin of the company.

Examples of export packing lists are given on p. 359, *et. seq*. Methods of recording the data contained in packing lists are given on p. 476.

Structural Steel.—The packing lists issued by companies familiar with export shipment are extremely detailed, and it is possible to locate on them every separate member of the structure. The system employed by these companies, moreover, and the thoroughness with which it is carried out, renders it quite unnecessary to check their packing lists in detail. For **office buildings,** etc., a rough, general summary by weight of the columns, beams, etc., for each tier may be made and recorded for purposes of general information, and the final weight compared with the estimate. For **mill buildings,** etc., a similar summary will be found useful, also, for record for future estimating. For **bridges,** it is usually possible, without much work, to check off the main members; but a summary by, for example (on trestle bridges) girders, girder laterals, posts, transverse bracing, longitudinal bracing and fittings, will be found useful for future calculations, and may be used to check the shipment by applying to unit values.

In general, see that all the material called for in the specifications is mentioned in the packing lists, as misunderstandings regarding the material to be supplied are not uncommon.

Pipe and Fittings.—The checking of a packing list of miscellaneous pipe and fittings for a special installation involves considerable work, but, if possible, it should be conscientiously performed, as omission of important material is of not infrequent occurrence. If the material is ordered by a list such as is indicated on p. 200, it is usually easy to check against this list, and any omission can be noted. A lot of random material, however, is often difficult to identify, and in such cases it will often save time to prepare tables similar to the one shown on p. 200, one being filled out from the list of material ordered, and the other from the material given on the packing list. On completion, a comparison of the two lists will at once indicate any short shipment of material.

Boilers.—These can readily be checked, the only portion of the list requiring special attention being that covering the fittings, which are often short-shipped on account of a misunderstanding of the specifications.

Steam Engines, Etc.—It is not often that any important part will be overlooked in shipping; but such details as anchor-bolts, throttle valve, etc., are often omitted on account of misunderstandings regarding the furnishing of the same.

Tanks and Sheet Metal Work.—This material, usually shipped knocked down, is often hard to identify. Care should be taken to summarize and identify as much of the material as possible, however. The

total shipping weight should be compared with the estimated, and any serious difference investigated.

Conveyors, Elevators, Etc.—For a large installation of conveyors and elevators, knocked down for export, a complete check of the packing list is impracticable. A few pieces as shown on the drawings may be taken at random, however, and sought for on the packing list, and any serious short shipment can thus be caught. The actual shipping weight as compared with the estimate will also give a clue to any considerable shortage.

Transmission Material.—An installation of shafting, pulleys, hangers, etc., should always be ordered by list, and the packing list can readily be checked against this. Any short shipment can, therefore, be promptly found and corrected.

Small Steam Pumps, Etc.—Check the main items of the shipment, and note particularly the listing of anchor-bolts, throttle valve, exhaust valve and sight-feed lubricator, which are always "extras" and are subject to misunderstandings between the order and the proposal.

Large, Special Machinery.—This should be thoroughly checked against the drawings and specifications, as errors of far-fetched origin often creep in on this class of work, which may sometimes be caught by a careful checking of the packing list.

Ship's Permit

This is a permit issued by the steamship company to allow goods to be accepted by their stevedore loading the ship. It is obtained on application to the company on giving them an approximate idea of the character of the shipment, such as "100 tons of pipe and fittings," etc. It is not necessary to submit the shipping list. In the case of large and varied shipments, however, a list of the larger and bulkier pieces should be submitted, giving approximate weights and dimensions.

The object of the permit is, of course, to allow the steamship company to know in advance what kind of freight is to be expected, and its destination; so that arrangements may be made for storing on the wharf and for loading the steamer. The permit is to be surrendered to the stevedore by the drayman or other person appearing with the goods.

Pier Receipts

These are receipts issued by the steamship company as each batch of goods on a shipment is delivered at the pier. When the shipment is entirely delivered, shipper's manifests submitted, and other formalities complied with, the pier receipts are surrendered to the steamship company who then issue to the shippers their formal bill of lading.

The amount of detail information to be recorded on these receipts

varies with the requirements of the steamship company; usually they may be condensed from the packing lists. An example of a Pier Receipt, properly filled out, is given by Fig. 126.

Shipper's Manifests

The heading for a shipper's manifest as required by the U. S. custom authorities, together with the form of declaration that is printed on the back of the sheet, are given in Figs. 127 and 128; a list of instructions regarding the filling out of the blanks is not reproduced here. It will be seen that it is practically an invoice of special form, containing also information as to name of steamer and master, and name of port at which the material is to be landed.

NOT NEGOTIABLE

ORIGINAL

TEHUANTEPEC A-H ROUTE

AMERICAN-HAWAIIAN STEAMSHIP CO.

DEARBORN & LAPHAM, General Agents

OFFICE, 8 BRIDGE STREET, NEW YORK

Pier No. 7 Bush Terminal Co., Foot of 41st St., South Brooklyn

B/L NO.________

PRO. No ________

ORIGINAL POINT OF SHIPMENT________

ADVANCED CHARGES________

New York Jan 12 191 2

Received from Black Export Co. in apparent good order

intended to be transported by the S. S. Oregonian

subject to all conditions of American-Hawaiian Steamship Company's Bill of Lading

THIS RECEIPT MUST BE EXCHANGED FOR BILL OF LADING at Main Office, 8 Bridge St., New York City

Marks and Case Numbers		No. Pkgs.	Articles and Contents	Weight #
H I W / 212 / HON	Nos 31 to 46	16	Boxes Sugar Machinery	8,600
	47 to 48	2	Crates " "	2,400
	49	1	Skid " "	5,600
			Total	16,600

CONSIGNEE Harvey Iron Works Co.,

DESTINATION Honolulu, T.H.

VALUE OF SHIPMENT $ 1900 for United States Customs purposes

Full name of consignee must be given on this Receipt, or if consigned to Order then name of party to be notified at destination.

Each package should be noted and numbered hereon

Trucks take 39th Street Ferry foot of Whitehall Street, New York City

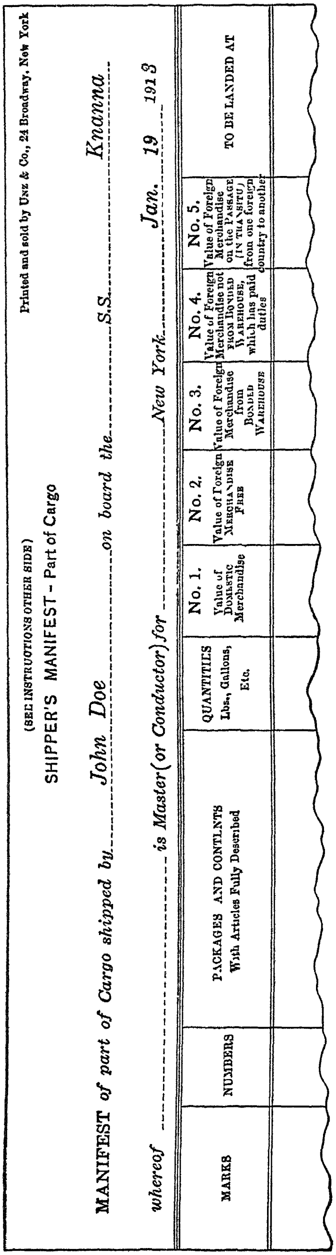
RECEIPT NO.________

PIER RECEIPT

Fig. 126.—Example of pier receipt form.

The object of this shipper's manifest is to give information to the U. S. authorities concerning goods that are being sent out of the country, both for statistical purposes and also to make sure that the neutrality laws, etc., are not being infringed. The blanks can be purchased at the customs house or from any stationery firm dealing in this class of goods, and are filled out by the shipper and forwarded to the steamship company, who will not issue a clean bill of lading until they obtain this manifest, duly sworn to and certified by the U. S. authorities. From these manifests

the "ship's manifest" is made up and "clearance papers" for the ship obtained by the captain from the U. S. custom house. Any ship sailing without these papers is adjudged a pirate.


Printed and sold by Unz & Co., 24 Broadway, New York

(SEE INSTRUCTIONS OTHER SIDE)

SHIPPER'S MANIFEST - Part of Cargo

MANIFEST *of part of Cargo shipped by* John Doe *on board the* S.S. Knanna

whereof ______ *is Master (or Conductor) for* New York Jan. 19 1913

MARKS	NUMBERS	PACKAGES AND CONTENTS With Articles Fully Described	QUANTITIES Lbs., Gallons, Etc.	No. 1. Value of Domestic Merchandise	No. 2. Value of Foreign Merchandise Free	No. 3. Value of Foreign Merchandise from Bonded Warehouse	No. 4. Value of Foreign Merchandise not from Bonded Warehouse, which has paid duties	No. 5. Value of Foreign Merchandise on the Passage (in transitu) from one foreign country to another	TO BE LANDED AT

FIG. 127.—Heading of shipper's manifest.

As to the amount of information that is to be given on these sheets it may be said that nothing like a detailed shipping list is required on the one hand, nor can a blanket invoice, covering a variety of material, be used on the other. As stated in the "instructions," merchandise must be quoted in specific and not general terms. It is not sufficient to specify "machinery" or "machines;" the kind should be stated, whether electrical, printing presses, pumps, typewriters, etc. However, a large and varied assortment of (say) sugar-factory machinery may be entered on one sheet by allowing a line for each class of apparatus; such as 50 pieces, numbered 301–350, of "centrifugal sugar-drying machinery;" 110 pieces, numbered 451–560, of "sugar-cane roller-mill machinery," etc., etc. Likewise, belting, pulleys and shafting, etc., should be kept separate.

Shipper's Manifests, properly passed by the custom house authorities, are also known as "Custom House Clearances."

No charge is made by the custom house authorities for certifying manifests.

Bills of Lading (Export)

The definition given for a domestic B/L applies also to the export B/L. It is a receipt issued by the transportation company for the acceptance of certain goods, and is also a contract for their delivery at a place specified according to certain terms and conditions.

Except as governed by the consular regulations of certain countries, the goods may be consigned "direct" or

"to order;" there being no difference in the form of the B/L as is the case in domestic B/L's.

An example of an export bill of lading is given by Fig. 129. The blank sheets can be obtained from the steamship company and filled in as far as possible by the shipper. It will be seen that, when properly filled out, they give information as to the name of the shipper, steamship, port of delivery, name of consignee; number, class mark, description, and weight of packages; date, freight charges, miscellaneous conditions, and the signature of the agent.

In the case of large shipments, "pier receipts" (p. 362) are issued by the steamship company for each batch of goods and are exchanged for a B/L on completion of delivery. The B/L and freight charges on same are made up from the steamship company's office record of "ship's receipts."

DISTRICT AND PORT OF NEW YORK

I——————————do solemnly and truly swear that the within Manifest contains a full, just and true account of all the goods, wares and merchandise shipped by——————————on board the within named vessel (or vehicle) and that the quantities and values of each article are truly stated, according to their actual cost, or the values which they truly bear in this port at this time.

And I further swear that the said goods, wares and merchandise are truly intended to be exported to

Sworn to before me this —— day of ————, 1913.

Acting Deputy Collector.

FIG. 128.—Form of declaration on back of manifest.

For large and varied shipments, as, for example, material for a complete factory building, a summary of particulars of the packages is given on the back of the B/L.

Bills of lading are made out in triplicate, etc., according to the requirements of the people concerned. One copy is retained by the steamship company, one goes with the vessel, one (the original) is sent to the consignee or his agent, and the shipping agents, etc., usually require one for their files. Also several copies of the bill of lading are required by the consular authorities of some countries. (See p. 368.)

Signed bills of lading are not issued by the steamship company until a properly indorsed "shipper's manifest" (issued by the custom house authorities) covering the part of the cargo in question, is presented to them. (See p. 363.)

INVOICE (EXPORT)

An ordinary invoice (not consular) for goods for export shipment, differs in no essential feature from an invoice for a domestic shipment (see p. 330), except that it is usually more complete.

In addition to containing particulars of each parcel of goods, the amount of the freight, consular fees, insurance, and other charges may be given, and also the name and address of the shipper and the consignee, steamer, date of sailing, etc.

An example of an export invoice is given in Fig. 130.

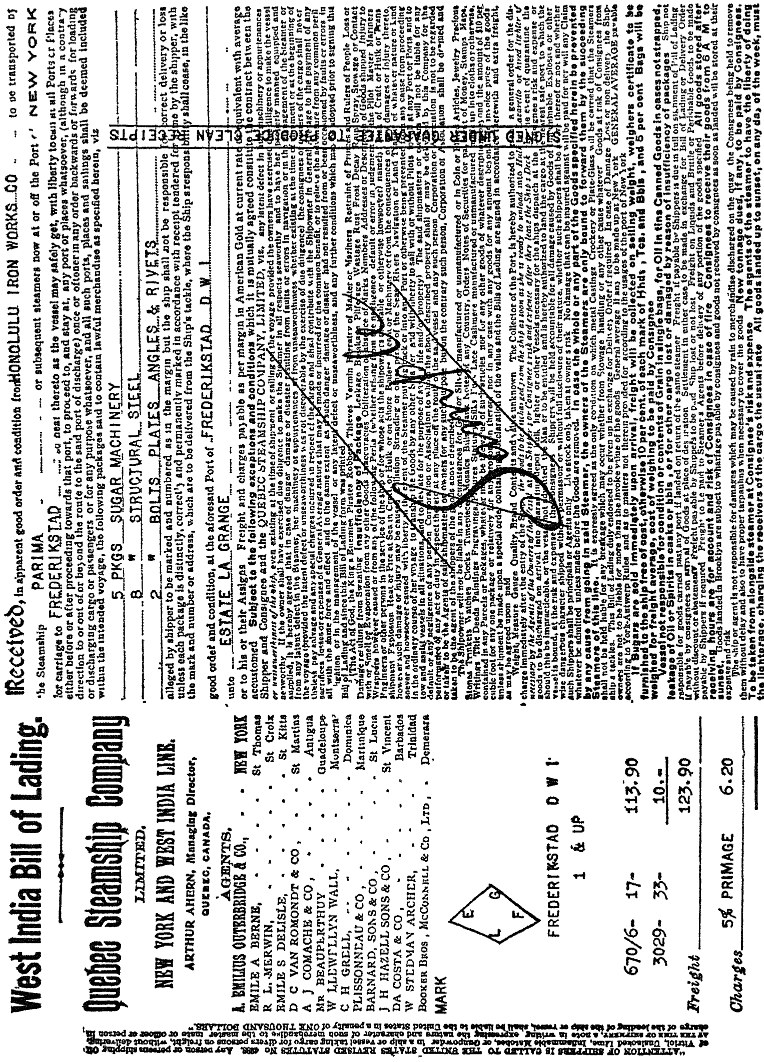


FIG. 129.—Example of export bill of lading.

MARINE INSURANCE

A great deal of special complexity occurs, also, in this branch of the export shipping business, but any attempt to explain its intricacies would be of no particular interest in this volume.

The two general methods of insuring shipments are "insuring with average" and insuring "Free of particular average" or "f.p.a." as it is usually abbreviated. Under the first method, if a cargo is partially lost or damaged, insurance money can be collected according to the amount of damage done to the particular goods insured; while under the second method (f.p.a.) in case of partial loss or damage to the cargo as a whole,

176 *Stockton St.,*
Middlesboro-on-Tees,
July 17th, 1912

MESSRS. PRESTON, SELLERS & CO.,
150 Broadway,
New York, U. S. A.
Bought of WM. PALMER & CO., LTD.
Engineers.
Terms: Net Cash against bills of lading.

Sixteen (16) 7 ft. 0 in. diameter × 18 ft. 0 in. long. Patent Defecators

(Wm. P. & Co.'s Nos. 17678—17693)
Complete with couplings, driving shaft and belts.

Per our "pro forma" invoice of	Mar. 26th, 1912		£258		
Freight and charges		£19–15–3			
Bills of lading		2–6			
Consuls fees		14–6			
Insurance and Policy		1–10–6	22	2	9
			£280	2	9
				net	

Order No. 617 Cont. No. Esperanza No. 5.

P——S
Mark 617
TAKAU

Shipped per the s/s "Falls of Clyde"

Certified correct.
WM. PALMER & CO., LTD.
Per . . . . .Director

FIG. 130.—Export invoice.

there can be collected on the particular goods in question only the percentage of their insured value that the cargo as a whole has suffered, irrespective of the actual damage done them. The charges for the first method are higher than for the second. By each method, of course, total loss calls for recovery of total insured value.

The usual method of insuring general machinery shipments is the second method described, "f.p.a." It might be desirable however to see that this policy covers any *breakage* during transit. Insurance is some-

times written to cover material on lighters both at shipping port and at port of entry, so as to doubly cover the risk of this part of the transportation, the railroad B/L being the first protection (at shipping port); in other words, the policy may cover the material "from railroad dock to landing dock."

Insurance rates are affected by the route, age and character of the vessel, season, cargo, stops made, transhipment en route, total amount of insurance on cargo, etc., etc. The rates are quoted in "cents per $100 value of shipment," or as a percentage. It is usual to insure a shipment for its invoice value + 10 percent, to cover freight charges, etc. The following examples will illustrate the rates usually paid, all being for first-class freight steamer shipment unless otherwise stated:

N. Y. to Cuba, 33 1/3 cents (.03 percent).

N. Y. to Honolulu via Tehuantepec route, 50 cents (.05 percent).

N. Y. to Philippine Islands via Suez Canal, 60 to 70 cents.

N. Y. to Honolulu by sailing vessel via Cape Horn 400 cents (4 percent).

The business of obtaining insurance is conducted by insurance brokers who "bring together" the shipper and the insurance office. When a vessel has almost a full cargo, for instance, it is often difficult to obtain insurance at the last minute, and a broker may have to call upon a dozen or more offices before he is able, finally, to place the business.

Consular Regulations of Foreign Countries

For complete information on this subject, the reader is referred to a bulletin with the above title bearing the Tariff Series No. 24, issued by the Bureau of Manufacturers of the U. S. Dept. of Commerce and Labor, Washington, D. C., where they may be obtained on request. The following remarks are extracted or compiled from the information found therein.

"This publication is intended for the use of manufacturers, merchants, exporters, shippers, and all other persons having occasion to forward merchandise to foreign countries. In some of these countries there are but few or no formalities to be observed in importing merchandise. In the case of other countries, especially those in the Western Hemisphere, it is necessary to attend to several preliminary matters before the shipments leave the United States. Thus, the invoice for the goods forwarded has to be taken before a consul of the country of destination at the port of embarkation and there sworn to as to its correctness and the good faith of the shipper. Some of the countries require in addition that the bills of lading be likewise certified by their consuls. The shipping manifests must likewise be taken before the consul by the captain of the boat and must be certified to be in agreement with the bills of lading and invoices for the goods which the boat is taking.

"The fees for the certification of these various documents differ very widely, from nominal sums to very substantial charges, which in some cases add materially

to the custom duties which have to be paid upon the arrival of the goods at their destination.

"Any attempt to avoid the payment of these charges is punishable by heavy penalities and frequently involves many delays and extreme annoyance to the merchants to whom the goods are sent or consigned. Lack of attention to these requirements with its consequent inconvenience and losses to the buyer or consignee has resulted in many instances in a complete loss to American exporters of what was otherwise a promising opening in a foreign market, and has been instrumental in injuring the reputation of American shippers generally."

Synopsis of Principal Consular Requirements for U. S. Shipments

(March, 1910)

Country	Cons. inv.	Certif of origin	B/L's required	Remarks
Argentina	No	Yes[1]	Yes	
Brazil	Yes	Yes[2]	No	
Canada	Yes[1]	No	No	Many amendments.
Cost Rica	Yes[1]	Yes[2]	No	
Cuba	Yes	Yes[2]	No	
Dominican Rep	Yes	No	Yes[2]	
Japan	No	Yes	No	
Mexico	Yes	Yes[2]	No	
Venezuela	Yes	No	Yes	Reg's very "tricky"

All above documents must be certified and fees paid therefor, except as noted.
In addition to the above, the following countries require consular observances:
In America: Bolivia, Chile, Colombia, Ecuador, Guatemala, Haiti, Honduras, Nicaragua, Panama, Paraguay, Peru, Salvador, and Uruguay.
In Europe: Greece, Italy, Portugal, Spain and Turkey.
In Africa: Egypt and Liberia.

In all other countries, "no formalities are imposed in connection with the importations of goods to these countries that would require the appearance of the shipper at the consulate of the respective country or the payment of any charges in connection therewith. But while goods can be shipped direct to any country not mentioned in this publication, without observing any formality or regulations other than those called for by the steamship companies or forwarding agencies, a certificate of origin, viséed by the appropriate consul, will sometimes facilitate the admission of articles, when entitled to entry at the lower of two or more rates of duty, or when there are special restrictions affecting importation from certain countries.

In addition to the fees charged by the foreign consulates in the United States, customs duties are imposed upon American goods upon their arrival at the countries of destination. Information as to foreign tariff can be obtained from the Bureau of Manufactures upon application."

For definitions of the terms "consular invoice," "certificate of origin," etc., see other headings in this chapter.

[1] No charge for certification
[2] Included in consular invoice

Consular Invoices

These are invoices made out in such a way as to facilitate the assessment of duties in the country of importation, with their accuracy sworn to before a consul of the importing country, and countersigned by him. In most cases they must be made out on special blanks to be obtained at the office of the consul; in others, no special form is required. A copy of the consular invoice of Cuba is given on p. 371; of Mexico on p. 372; and of Canada (together with one of the several alternate forms of declaration) on p. 371. It must be remembered that many countries require no consular certification of invoices. (See "Consular Requirements" on p. 369.)

The **amount of detail information to be given in these invoices,** or, in other words, the extent to which a mixed shipment must be subdivided, will depend, evidently, upon the difference in tariff charges upon different material in the country of importation. But it will often happen that a copy of the consular invoice will be the invoice sent to the purchaser, and for his convenience will be made out in considerable detail; so that business reasons and customs, as well as the consular regulations, will often determine the extent of the invoice make-up.

As to the **amount of the invoice upon which duty must be paid,** the regulations vary; but in general it may be said that duty is charged on all values and expenses incurred up to the time that the goods are placed on board the vessel. Thus the cost of packing, domestic freight charges to the pier, storage charges, commission, custom house and statistical fees, papers and stamps, wharfage, etc., are usually included in the dutiable price; but ocean freight, primage and insurance, and consuls fees, are not included. These extras therefore, which must appear on the invoice, should be billed separately. (See example on p. 367.)

As many as **six or seven copies of these invoices are sometimes required.** The consul keeps one and sends two others to the receiving custom-house and to customs headquarters respectively, one and sometimes two are required by the receiving custom-house, and the shipper and the purchaser require one each for their files; the latter two copies need not, of course, be certified by the consul.

A small **charge** is usually made for the blank invoices. A consular fee is usually charged for certification depending upon the amount of the invoice; extra copies are certified for a small extra fee.

The **requirements of the different nations** in respect to consular invoices are given in complete form in the bulletin "Tariff Series No. 24" of the Bureau of Manufactures, Washington, D. C., where they may be obtained on application.

(M.)

SPECIMEN FORM OF INVOICE APPROVED BY CANADIAN CUSTOMS (JANUARY, 1910) FOR GOODS SOLD BY EXPORTER PRIOR TO SHIPMENT

(Place and date)————

Invoice of ————, purchased by ————, of———, from————— of ———, to be shipped per——.

Marks and numbers on packages	Quantities and description of goods	Fair market value as sold for home consumption at time shipped.	Selling price to the purchaser in Canada	
			@	Amount

CERTIFICATE FORM "M."

I, the undersigned, do hereby certify as follows:

(1) That I am the ———[1] exporter of the goods in the within invoice mentioned or described;

(2) That the said invoice is in all respects correct and true;

(3) That the said invoice contains a true and full statement showing the price actually paid or to be paid for the said goods, the actual quantity thereof, and all charges thereon;

(4) That the said invoice also exhibits the fair market value of the said goods at the time and place of their direct exportation to Canada and as when sold at the same time and place in like quantity and condition for home consumption, in the principal markets of the country whence exported directly to Canada, without any discount or deduction for cash, or on account of any drawback or bounty, or on account of any royalty actually payable thereon, or payable thereon when sold for home consumption but not payable when exported, or on account of the exportation thereof, or for any special consideration whatever;

(5) That no different invoice of the goods mentioned in said invoice has been or will be furnished to anyone; and

(6) That no arrangement or understanding affecting the purchase price of the said goods has been or will be made or entered into between the said exporter and purchaser or by anyone on behalf of either of them, either by way of discount, rebate, salary, compensation, or in any manner whatsoever other than as shown in the said invoice.

Dated at——————this—————day of ———, 191—.

(Signature)—————.

[Copy of consular invoice of Cuba]

Factura de mercancías embarcadas por————, á bordo de———, con destino
Invoice of merchandise shipped by on board destined
á——, por cuenta y riesgo de———, y á la consignación de ——————.
for for account and risk of and consigned to

Marcas y números Marks and numbers	Número de bultos Number of packages	Descripción Description (Detailed contents componen material)	Peso bruto Gross weight.	Peso neto Net weight	Precio Price	Valor Value
			Kilos	*Kilos*		

[1] Insert the word partner, manager, chief clerk, or principal official, giving rank as the case may be.

Declaro que soy el————————de las mercancías, relacionadas en la presente factura y que son ciertos los precios y demás particulares que en ella se consignan, [a] y que las mercancías contenidas en dicha factura son productos del suelo ó de la industria de los Estados Unidos de América.

Declaro que soy el agente autorizado por Don—————, que ha suscrito la anterior declaración, para presentar esta factura en la oficina consular de Cuba en esta plaza, á fin de que sea certificada.[a]

No.———.

CONSUL GENERAL DE LA REPUBLICA DE CUBA EN NEW YORK

Certifico; Que la presenta factura compuesta de———— hojas, selladas con el de este consulado, me ha sido exhibida por el firmante de la declaración que antecede vada en esta oficina.

Lo que firmo y sello con el de este consulado general en New York á————————

Derechos—.

Artículo 21 del Arancel.

FORM No. 7. [Copy of consular invoice of Mexico]

Invoice of merchandise shipped by the undersigned, on board the ——— whereof ———————————is master, and consigned to ——————— of the port of——in the Republic of Mexico, to which port the vessel is bound.

Mark of package	No of each package	Quantity of packages	Description of packages	Gross weight of each package in American pounds	Total net weight in American pounds	Total legal weight in American pounds	Class of merchandise	Place of manufacture	Value in U. S. gold

Date, protest and signature of shipper to be placed at the end of the invoice.

Instructions.—Every package must be marked and numbered.

The number of packages must be added at the foot of each invoice in figures and writing.

Erasures, corrections and writing between lines not allowed. Any non-compliance with the foregoing instructions will subject the importers to a fine in each case.

The declarations of the "class of merchandise" should be in conformity with the vocabulary of the Mexican customs house tariff.

CERTIFICATES OF ORIGIN

These are declarations required by the consular regulations of certain countries, giving information as to the country of manufacture or growth of the merchandise being shipped. The object of these declarations is to enable the customs authorities in the country of importation to assess the proper duties, preferential tariffs being often granted to "favored nations" on various lines of goods.

The declaration of origin is sometimes placed at the head and sometimes at the end of the consular invoice (see the Cuban invoice above); in some cases the country of origin is indicated in a column of the consular invoice; and in other cases (as when no certified invoice is required) a separate form is used (see the form for Japanese shipments below).

Fees are usually charged for certifying these certificates, or for the blanks or for both.

The requirements of the different nations in respect to these certificates are given in complete form in the bulletin "Tariff Series No. 24" of the Bureau of Manufactures, Washington, D. C., where they may be obtained on application.

DECLARATION AND OATH AS TO AMERICAN PRODUCTS OR MANUFACTURES EXPORTED TO JAPAN

Marks	Numbers	No of packages	Description of articles	Quantities or weights	Place of production or manufacture	Place of shipment	Date of shipment

United States of America, State of———, County of———, City of————, *ss:*

I, ———, do solemnly, sincerely, and truly swear that I am————*a* of——— ——office at ——— city of ————, State of —————, U. S. A., ——— *b* of the above-described articles, consigned to —————& Co. of ———, Japan, per steamship————— to leave the port of ————, State of ———, on or about —————, 19—; that all the said articles are respectively, truly, and bona fide the ——*x* in each case of the place above mentioned in the United States of America, and that in all other respects the foregoing statement as to said articles is true to the best of my knowledge and belief.

[Signature of person making the declaration.]

Sworn to before me this ——— day of ———, 19—.
[L.S.] ——————————, *Notary Public.*

Customs Tariffs of Foreign Countries

The engineer or contractor is concerned with these tariffs only when making estimates or quotations for material delivered or erected in the country in question, to include all charges of whatever nature. The occasional exporter will rarely quote this way; his price may be based on the material delivered free in ship's tackles (c.i.f.) at the foreign port of entry, but the importer usually takes care of the customs duties and landing charges himself.

For a complete schedule of the customs tariff's of all nations, see the "Shipping World Year Book,"[1] by Evan Rowland Jones; or the bulletins issued by the Bureau of Manufactures of the Dept. of Commerce and Labor, Washington, D. C.

SEC. II. DESIGNING AND PACKING FOR EXPORT SHIPMENT

Largest Pieces that Can Be Handled

The size and weight of the largest pieces that can be handled on the route of an export shipment is frequently a matter requiring careful

[1] "Shipping World" office, London; U. S. Agents, American Bureau of Foreign Trade, 29 Broadway, N. Y. City.

investigation. On nearly every large installation of machinery requiring transportation to a foreign country (often to a wild and inaccessible location), the question comes up as to the largest piece that it is desirable to ship in one package.

Taking up first the requirements of transportation by **mule-back,** the maximum package weight is usually taken at 350 lb. In an article in the "Eng. News" of Aug. 12, 1909 by F. C. Roberts and Walter W. Bradley on this subject, it is pointed out that by proper organization and good judgment in the selection of animals, loads as heavy as 500 lb., and (in exceptional cases) even as high as 680 lb. can be handled in one piece. It would appear, however, from the article in question, that a weight of between 400 and 450 lb. is about the maximum at which a piece should be designed, and that weights of this character run up the transportation costs very considerably. Pieces of shafting 13 ft. 6 in. long weighing 580 lb. were transported on the back of one mule by using one man to lead the animal, and another to balance the load.

In transporting long cables, "the coils were made up and tied with wire in the factory before shipping, each mule's load being divided into two parts, with about 12 ft. of cable between each pair of coils. The coils were so arranged that each mule load was about 236 lb."

Lengths of timber, etc., can be carried in pairs, slung on each side of two mules, one at each end.

With regard to tank plates, it is stated that an area of 17.5 sq. ft. per plate was the maximum, or pieces 5 ft. $\times$ 3 ft. 6 in.

Transportation by **small boats** is sometimes the only means of getting material to the building site. Conditions are so variable, however, that the limitations must be ascertained for each individual case.

The **unloading facilities** at the building site are often limited by natural conditions. On the coast of Hawaii, machinery is carried from the deck of the steamer to the top of the cliffs by means of cableways, the seaward end of the cable passing through a snatch-block on the mast of the vessel to a permanent anchor farther out to sea. Under such unusual conditions, again, the capacities of each case must be ascertained in advance.

The next condition in the upward scale that limits the size of the packages is the **capacity of the railroads** in the country of entry. The weight of the piece is not of much importance, as cars on gauges of 36 in. and less can carry loads of 20 tons and over; but the clearance limits of tunnels, bridges and sidings are factors to be reckoned with. Typical clearances for various gauges are given in Figs. 109 to 113, but in doubtful cases the actual limits for the line in question should be obtained. As far as the loading and unloading facilities of the railroad are concerned there need be no question, as heavy pieces are invariably skidded and can be slid on and off the cars on to blocking.

The **handling between the steamer and the dock** at the port of entry is rarely a matter of question. As will be explained later, the steamship can always lift out of its hold and deposit on a wharf anything that is put into her. In the event that the boat cannot come alongside the wharf but must discharge on to lighters in the roadstead, it will often happen that, in order to handle a heavy load at the dock, a special gin-pole, shear-legs or gantry may have to be erected; this can, if necessary, be a temporary, inexpensive structure.

Now with regard to the **capacities of steamships,** it may be said that the large, modern freighters can handle anything that the railroad can bring to them, and may, indeed, in most cases do better; so that, if very bulky or very heavy pieces are manufactured at the seaboard, so that they may be loaded directly on to lighters, the ship may readily take them when the railroad could not. An **exception** occurs in the case of very long plate girders; these are frequently shipped on cars in lengths of 110 to 120 ft.; no steamer would handle such pieces, and for export shipment they would have to be made in two, or better, in three lengths with their field splices specially designed (see p. 389).

American wharves are rarely provided with cranes or derricks of any description, so that the lighter material is handled by the ship's tackle, and the heavier pieces by special derrick lighters. The **ship's booms** are usually rigged for a capacity up to about 5 tons with a maximum capacity of about 10 tons by special rigging. However, freighters usually carry a **special boom,** with a step-plate to rest on the deck, which can be rigged to handle weights up to 30 or 35 tons. This is made use of in such domestic or foreign harbors as have no means of handling very heavy pieces. The larger **derrick lighters** have steel booms and can handle pieces up to 30 or 35 tons; they are practically floating cranes with space on their decks for carrying material; and they are variously used for lifting material from cars to their own decks, transporting alongside steamer and there unloading, or for loading and unloading from a storage dock. They are hired by the steamship company for these purposes, and a large proportion of the "heavy lift" charges goes to pay for their use.

The **size of the steamship hatch** must sometimes be considered, especially in the case of long pieces. On the larger freighters the hatches are about 30 ft. × 50 ft. in size, but as the decks are about 10 ft. high, pieces longer than the length of the hatch can readily be placed in the hold. However, 50 ft. is about the longest length which it is generally advisable to ship in one piece when the girder is deep and heavy; light, shallow, girders (for hand-cranes) up to 75 ft. will, sometimes, be accepted by special arrangement.

The following **examples of heavy shipments** will serve to illustrate **average** capacities, they do not represent maximum conditions.

(1) Cylindrical sheet-steel "crystallizers," 9 ft. 0 in. diameter × 21 ft.

0 in. long overall, weighing 21,000 lb. each were placed by a derrick-lighter into a modern freighter in New York Harbor, and were finally placed on lighters in an open roadstead in Formosa.

(2) Plate-girders 45 ft. 0 in. long × 7 ft. 3 in. deep × 18 in. flange, weighing 6 tons each, and half-girders 40 ft. 0 in. long × 7 ft. 3 in. deep × 20 in. flange, weighing 7 1/2 tons each, were placed by derrick-lighters into the hold of a modern freighter in New York Harbor, transported across the isthmus of Tehuantepec by rail, loaded into a steamer on the Pacific side and deposited on lighters in a harbor in Hawaii, from whence they were picked up by a gantry on a wharf and placed on flat cars. As it was not deemed advisable to ship such pieces in longer lengths than this, girders 72 ft. 0 in. long × 7 ft. 3 in. deep were shipped in 36 ft. lengths and spliced in the field.

(3) An engine-bed for a 30 in. × 60 in. Corliss Engine weighing 33,400 lb.; 20 ft. diameter flywheels in halves of 27,500 lb. each; gear wheels, 12 ft. diameter × 18 in. face, weighing 21,500 lb.; sugar mill rolls 34 in. diameter on shafts 14 ft. 6 in. long, weighing 24,000 lb.; were placed on board a steamer in New York Harbor by a derrick lighter and transferred to barges in an open roadstead in Formosa. Similar material, in which the individual pieces weighed about 25 percent more than the above, was delivered on a wharf in an isolated location in the Philippine Islands, using the heavy boom carried by freighters for this purpose (see p. 375 and Fig. 152).

Packing for Export Shipment; Instructions and Examples

The remarks on packing for domestic shipment (p. 343) also apply very largely where the material is to be carried by steamer, except that provision has to be made for the increased amount of handling in slings. All the suggestions of that section therefore, should be considered in connection with the alternate and additional notes given below. Special consideration has to be given to securing compact packages, so as to reduce the excess charges on bulky pieces to a minimum (see p. 356).

A particularly aggravating example of poor packing recently came to the writer's attention in the case of the shipment of a large vacuum pan from New York Harbor to a Cuban port. Several frameworks of light metal rings, bent to a 12 ft. circle and cut so as to splice at the 120° points were shipped riveted to the supporting vertical angles. The gross weight of the whole was only about 4,000 lb., but the measurement was about 1,000 cu. ft., and the freight charge (at 14 cents per cu. ft.) was $140 for this one item. Had the material been knocked-down and nested, the bulk could have been reduced to about 200 cu. ft. and the charge would have been only $28, making a clear loss to the shipper of $112 on this portion of the shipment alone. The manufacturer was paid on delivery

f.a.s. and had no direct interest in the matter, but the oversight would undoubtedly have been caught by a wide-awake inspector.

No hard and fast rules can be laid down as to the packing required for particular apparatus; the amount and roughness of handling incidental to

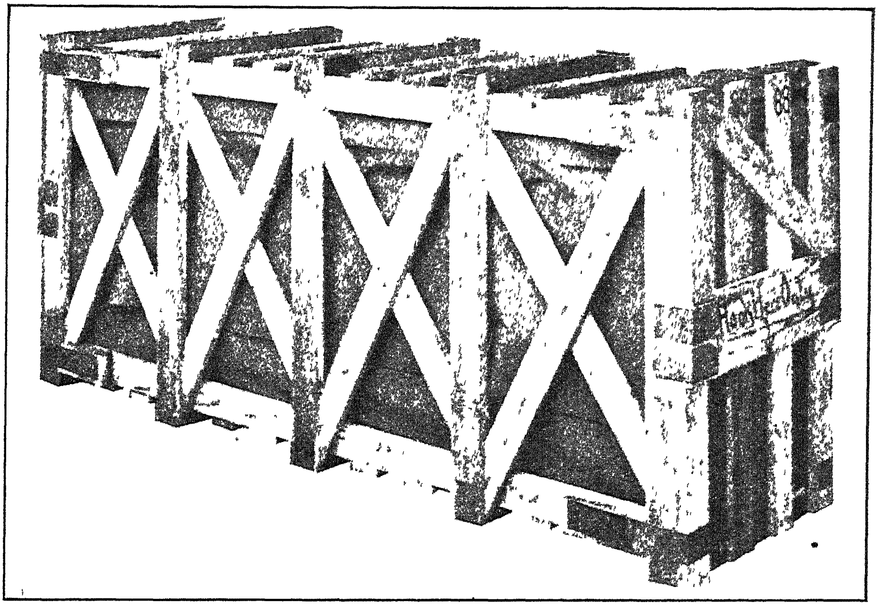


FIG. 131.—Reinforcing metal packed for export shipment (Trussed Concrete Steel Co.).

the route must always be considered. The following descriptions, however, will indicate to the engineer and inspector the usual methods used when packing material for export shipment.

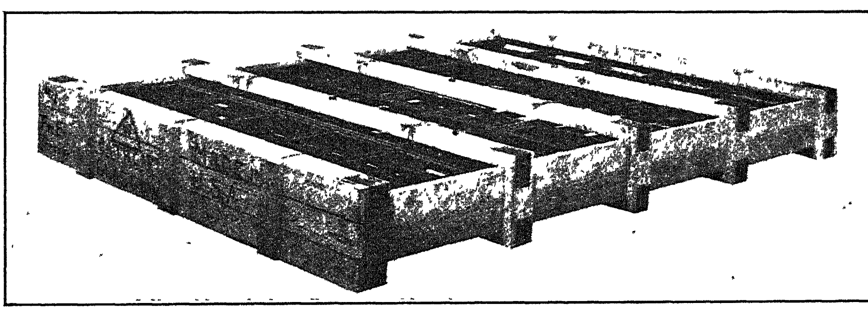


FIG. 132.—Steel sash packed for export shipment (Trussed Concrete Steel Co.).

With regard to **machine-tools, small and medium-sized engines,** etc., not only the smaller machines but also those of considerable bulk may be entirely boxed. The larger and heavier articles of this (fragile) type

should first be placed on skids and the boxing built around the whole, braces and buffers being inserted as the boxing proceeds. The loose

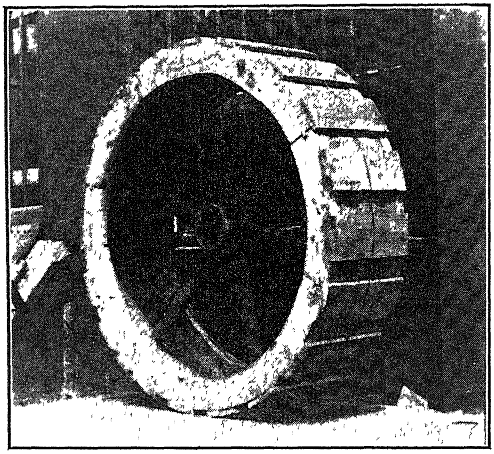


FIG. 133.—Band wheel, about 4 ft. in diameter, protected for shipment.

pieces and accessories may be advantageously secured inside the box. To give greater stiffness to the sides, these may be built "sandwiched,"

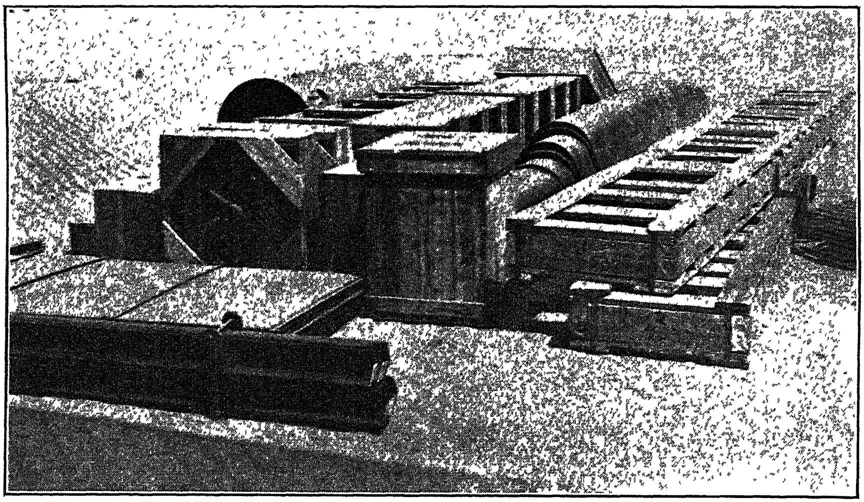


FIG. 134.—Miscellaneous material packed for export: on the right, locomotive frames crated; next, scroll-conveyor troughs nested for shipment; next, scrolls for same crated; on the left, a small vertical boiler, head has a wooden protector bolted on; in front, angles and plates (stock material) nested and bolted together; behind them, a C. I. pulley crated.

i.e., of two layers placed diagonally or at right-angles; and if the second layer is put on after the boxing is complete, and arranged so that the new

sides will cover the old ends, a boxing of great resistance will be the result. For the more **delicate machinery,** a layer of tarred-paper, etc., may be placed between the courses. Boxed packages as large as 850 cu. ft. may

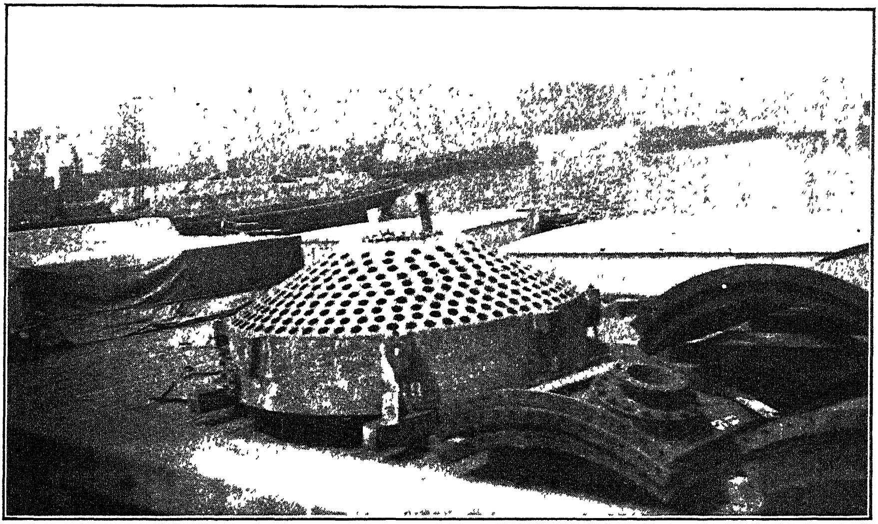


FIG. 135.—Parts of a 10 ft. 6 in. diam. calandria vacuum pan. Calandria of cast brass, 10 ft. 0 in. diam., weighing 9000 lb., with tubes expanded-in.

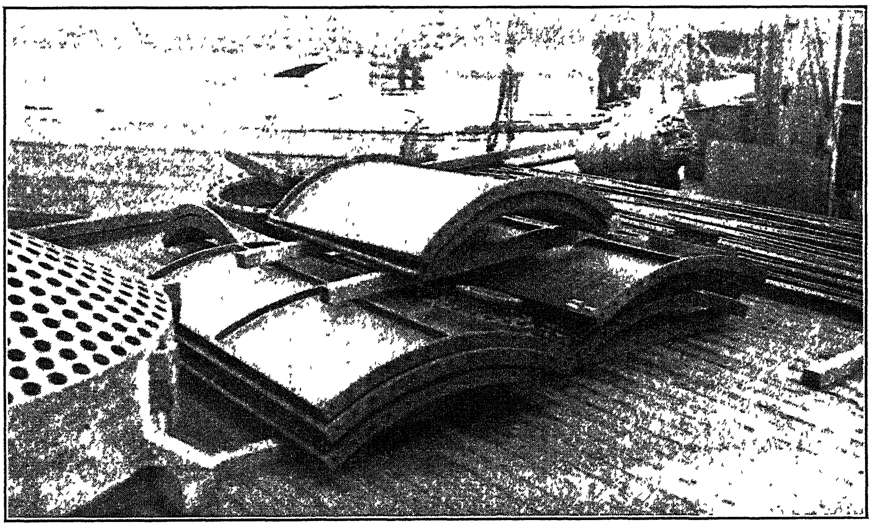


FIG. 136.—Portions of belt of a 10 ft. 6 in. diam. vacuum pan. The larger pieces are 5 ft. 6 in. × 9 ft. 0 in. × 1 ft. 0 in. and weigh 2,200 lb. each.

sometimes be advantageously shipped. The most **delicate** types of **machinery or instruments,** such as type-setting machines, laboratory apparatus, etc., should, in certain cases, be enclosed in zinc or tin.

Lathes.—Small lathes should be completely boxed as described above. Lathes of a size 28 in.×14 ft. and larger may be shipped "upside down," the top being first boxed in and skids placed on top. The bed will then

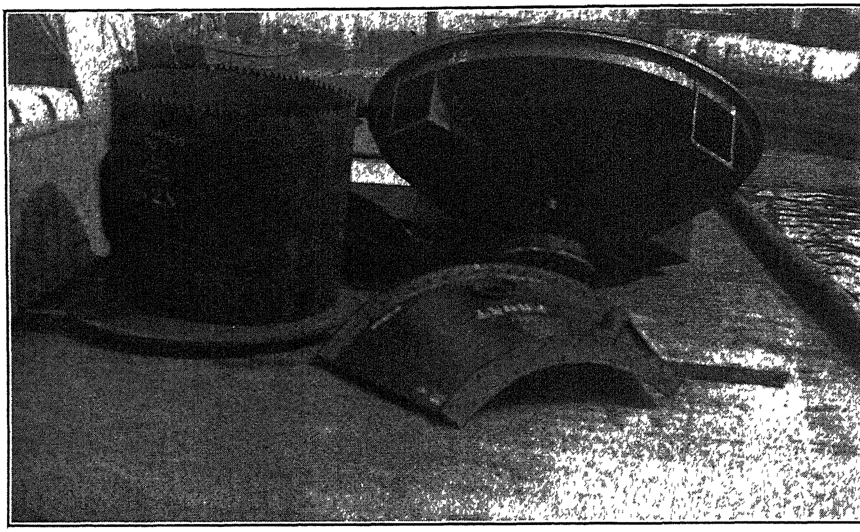


FIG. 137.—Parts of a 10 ft. 6 in. diam. vacuum pan. The bottom piece is 11 ft. 3 in. diam. × 4 ft. 0 in. deep and weighs 6,500 lb.

FIG. 138.—A cast-iron evaporator dome of 10 ft.diam. shipped from France and trans-shipped in New York to the West Indies: an example of careful packing.

be exposed, but the legs should be boxed, bracing from the main boxing. The largest lathes will be shipped K.D.

Locomotives, even of the smaller sizes, are shipped in a completely

knocked-down shape. The boiler, wheels, trucks and tender truck need not be cased; but the cab, cylinders, connecting-rods, frames, etc., and the tender tank should be boxed or crated.

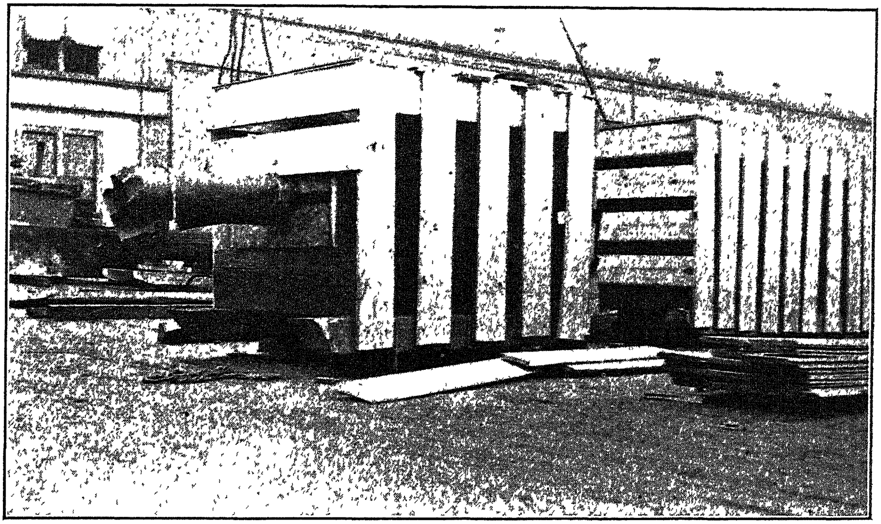


Fig. 139.—An electric generator packed for coast-wise shipment; the skidding and crating is not good enough for long sea shipment.

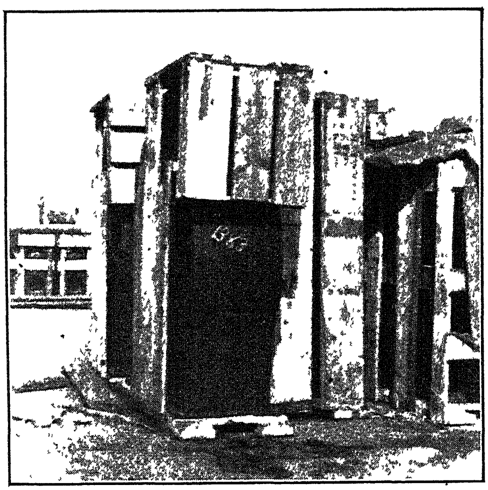


Fig. 140.—Blower crated for export; note crating over pulley and outboard bearing.

Small pumps shipped in one piece should be completely boxed.

Small engines up to about 9 in. × 9 in. may be skidded and crated (boxed for the smaller sizes) and shipped in one piece. Larger sizes will usually be K.D. When engines are crated, care must be taken that all

steam openings are plugged or have wooden covers bolted on; children playing about the railroad yards are apt to fill such openings with stones,

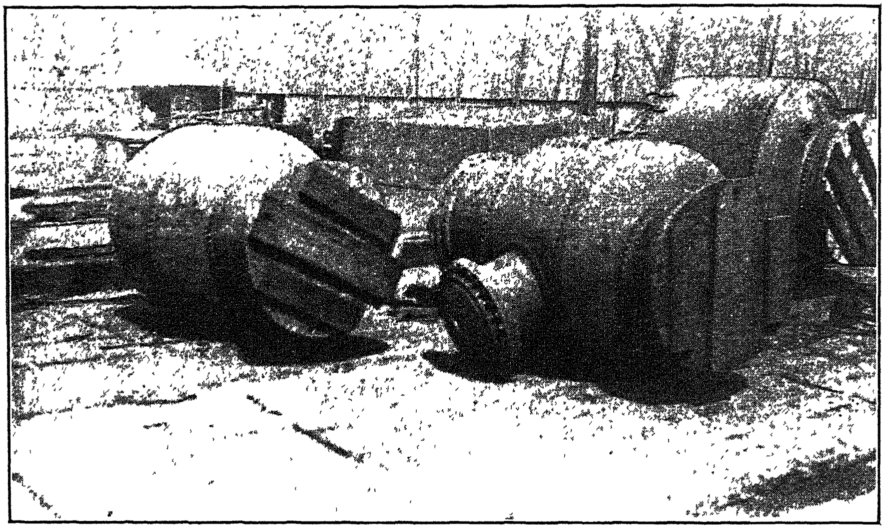


FIG. 141.—Two 42-in. and one 54-in oil separators, made of 5/16-in. and 3/8-in. sheet steel. The 42-in separators are 10 ft. long and weigh 5,400 lb. each; the 54-in. separator is 8 ft. long and weighs 6,240 lb. Note the end flange-protectors and the shackles for handling.

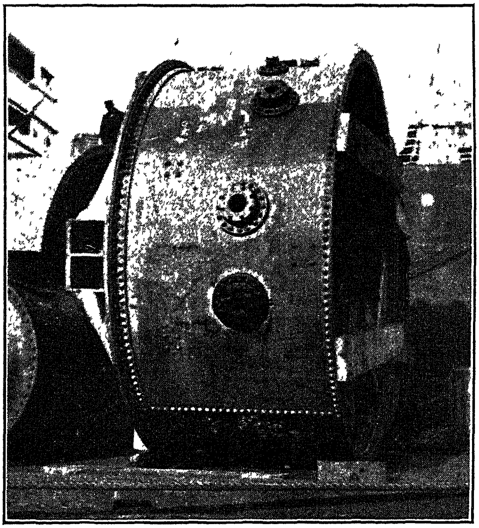


FIG. 142.—Another view of vacuum pan shown in Fig. 143, showing bracing.

dirt, etc., to the detriment of the operation of the engine. For the same reason oil holes, or any openings giving access to wearing parts, should be protected.

Pressed-steel pulleys, on a mixed order, may often be partially nested and a great saving in measurement made thereby. They must be well crated, however, after nesting, faces and sides being protected, and the circumferences being bound with iron strap or wire.

Cast-iron pulleys may not be nested, but should be crated separately, see Figs. 133 and 134.

Shafting is entirely boxed and wired.

Shafting hangers are boxed or crated.

Small pipe in stock lengths, up to about 2 in. in size, will have a coupling on one end, the other end protected with sacking, wrapped and tied on. The lengths are wired together in bundles of weight convenient for handling.

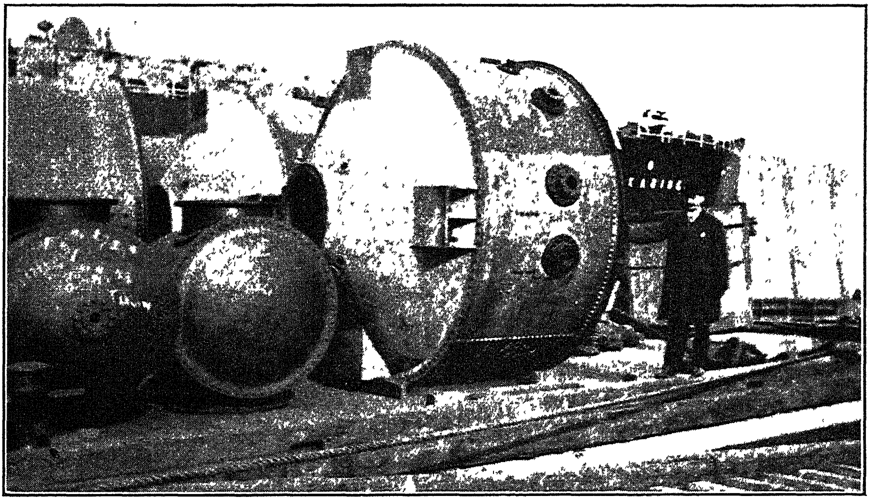


FIG. 143.—Lower section of a vacuum pan for export to Formosa, 11 ft diam. × 8 ft. 6 in. long, with calandria inside, gross weight 19,400 lb.; shell of steel, bottom of cast iron: flanges should have been protected.

Larger screwed pipe will have a coupling on one end, and on the other a metal collar screwed on so as to protect the threads; lengths must usually be handled singly.

Flanged pipe should have wooden protectors, the size of the flange, bolted on the ends to protect the flange faces.

Copper and brass piping, whether straight or bent, should be crated; this material is too soft to stand direct handling.

Traveling Cranes. Bridge girders over about 60 ft. long are usually shipped in halves, with a central field splice. The end trucks may be shipped "bare," with wooden protectors on finished wearing surfaces. Trolleys boxed or crated. Blocks crated. Chain boxed. Cage K.D. Electrical equipment boxed, with tarred paper wrapping.

Belting is rolled and completely boxed. Quite large belts can be readily shipped in one length; a 28-in., 6-ply conveying belt, 900 ft. long was rolled and boxed to form a cylindrical package 6 ft. 6 in. in diameter ×

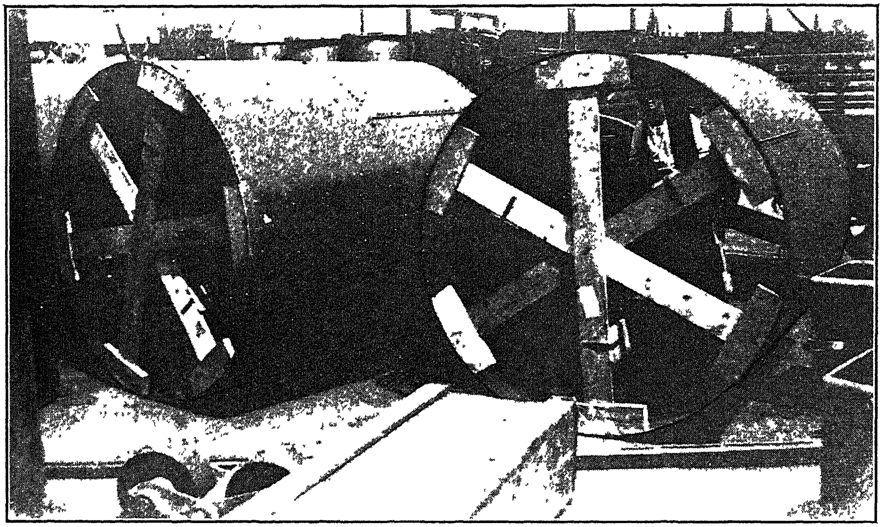


FIG. 144.—Sections of sugar-drier drum, 6 ft. diam. × 8 ft. long, braced for export shipment.

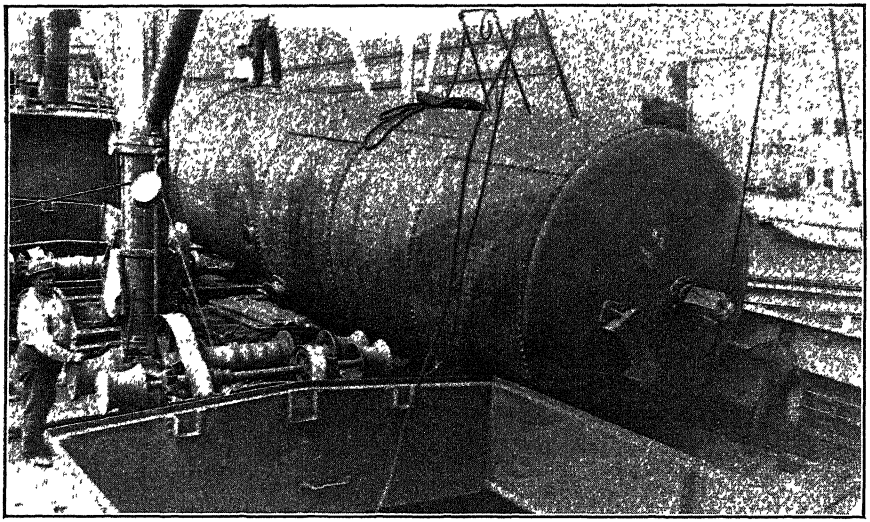


FIG. 145.—Crystallizers (for sugar factory) 9 ft. diam. × 22 ft. long on deck of small steamer.

3 ft. long, weighing, 5,800 lb. gross. Such a package is conveniently handled, and its weight and dimensions could be largely increased without presenting difficulties in handling.

Tanks usually present more or less difficulty of treatment.

Large tanks are, of course, shipped completely K.D., with bent plates nested to form packages weighing up to about 8,000 lb. each; so that on this material the "bulk weight" may be readily kept down to close to the actual gross weight.

Small tanks shipped riveted-up are liable to deformation due to rough handling, especially if made of very thin plates, and furthermore the "measurement" freight charges become excessive. If shipped K.D. the latter charge may be moderated but the expense of riveting-up in the field has to be met, and a certain amount of delay may be thus introduced. All these factors, first cost, freight charge, damage in transit, field erection

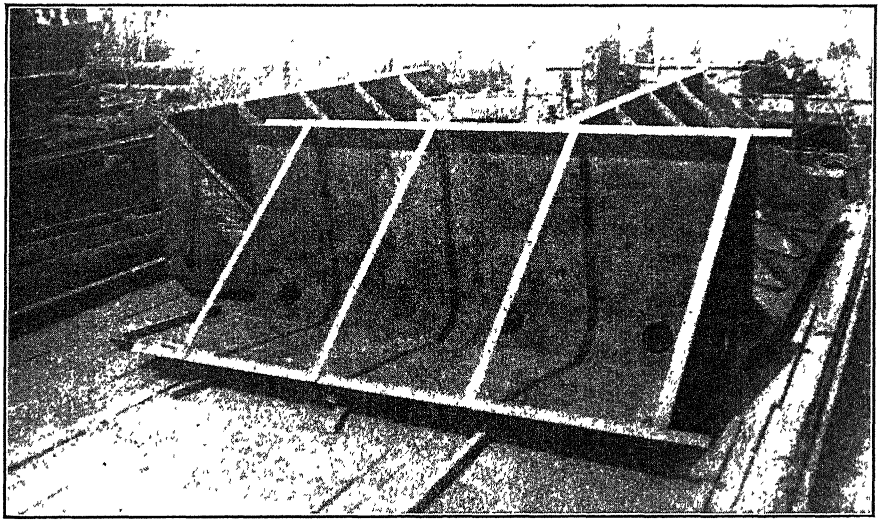


FIG. 146.—Section of "Mixer" for a sugar factory installation, 9 ft. wide × 8 ft. deep × 25 ft. long (1,800 cu. ft), weighing 9,550 lb. gross, made of 5/16-in. sheet steel braced with 4 × 4 × 1/2 angles.

difficulties and cost, and time, must be taken into consideration in order to arrive at a conclusion as to whether to order the tank K.D. or R.U.

A lot of small tanks for the same job may be designed so as to **nest** for shipment, **rectangular tanks** being made in a series of different sizes, and **cylindrical tanks** also made in sizes or else all designed as frustums of cones so that they will nest well.

Six to 10 ft. is about the maximum diameter that is ever advisable for **cylindrical tanks** to be shipped R.U.

Rectangular tanks shipped K.D. will have their bottoms flanged, ends flanged and corners scarfed, and sides flat with corners scarfed; the bulk is reduced to a minimum and field riveting is simple. Rectangular tanks, therefore, larger than about 4 ft. cube, should invariably be shipped K.D.

Both cylindrical and rectangular tanks shipped R.U. should be **braced** inside or across the top as may be necessary, and, if made of very thin material, must be **crated.**

Small Smoke Stacks may be shipped either partly or entirely knocked-down, depending on the amount of saving in freight charges that it is desired to make. For stacks up to about 24 in. in diameter, lengths of about 20 ft. may be riveted-up in the shop and these lengths crated; this will necessitate the use of flanged end connections so that the pieces may be assembled on the job. However, these small stacks are preferably shipped completely unriveted, each plate being bent to a complete circle and nested one within the other. In this manner, all the plates for a stack 80 or 100 ft. high may be shipped in one bundle having a di-

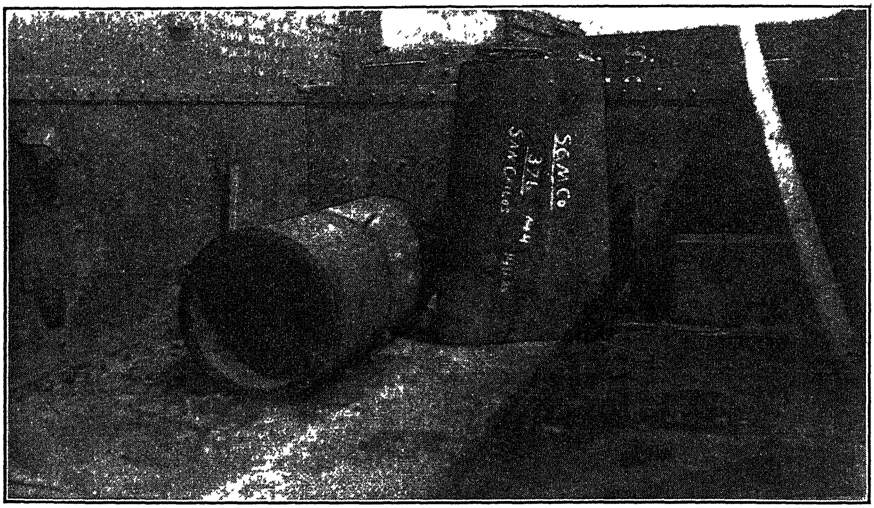


FIG. 147.—A 24-in. × 40-ft. steel smoke-stack knocked down and nested for shipment. One bundle 30 in. × 30 in. × 57 in., 1,107 lb.; and one brichin 36 in. × 36 in. × 36 in., 141 lb.

ameter a little greater than the diameter of the stack and a length of the length of one plate, say 4 or 5 ft.; the freight charge then becomes a minimum. A piece of strap iron inside and out, bolted together at the ends, will keep the plates together during shipment. See Fig. 147.

Large self-supporting **smoke stacks** are shipped entirely knocked-down. The stack plates, bent to the proper radius, may be nested and bolted together; on a 10-ft. diameter stack, a dozen plates, 5 ft. wide by 10 ft. long, may be bolted together to form one bundle weighing up to 8,000 lb. The interior angles, trolley tracks, etc., may all be nested and strapped and bolted together. The ladder for a 125-ft. stack, in 15-ft. lengths, may be strapped and bolted to form one bundle. The base-plate

casting will be shipped in sections of about 10 ft. long weighing about 700 lb. each. All stirrups for anchor-bolt connection to base may be shipped

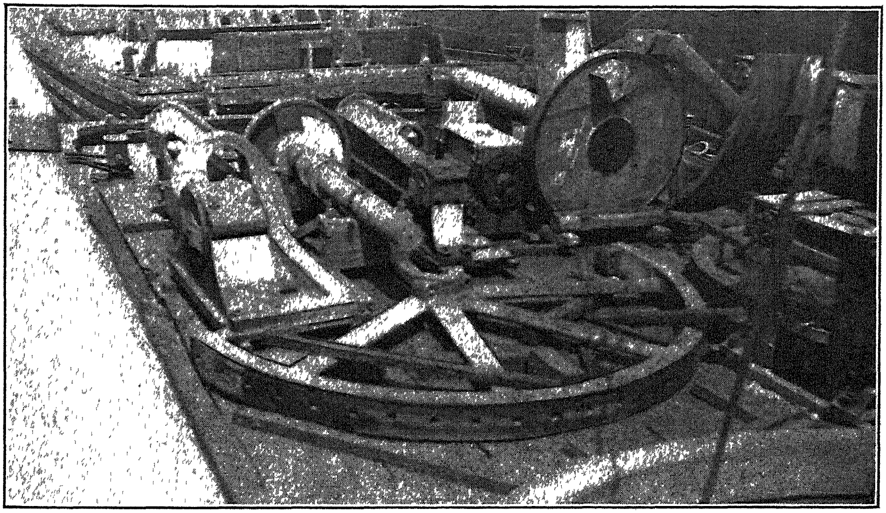


FIG. 148.—Parts of 18-in. × 42-in., 22-in. × 36-in. and 30-in. × 60-in. Corliss engines for shipment to the Philippine Islands. Note skidding and cradles for crank-shafts; boxing around crank-pin; protection at ends of pillow-blocks; and skidding and crating of cylinder.

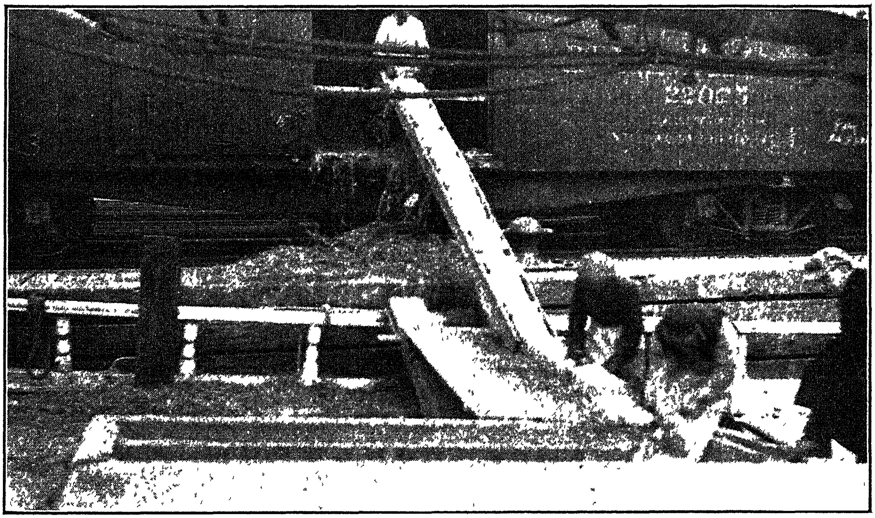


FIG. 149.—Loading firebrick shipped in bulk from cars to schooner. Fourteen cars carrying 200,000 brick, weighing 700 tons, in shipment.

loose, bolted together in bundles. Rivets and bolts are shipped in the usual small barrels or boxes. With a little care and foresight, the ocean

freight charges on such a bulky article as a large smoke stack may be reduced to a reasonable figure.

Large and heavy sheet-metal work, such as digesters, steam separators, etc., should have **shackles** riveted on so that they may be conveniently handled (see Fig. 141). This class of material needs no crating, but flanged faces, tube-plates, etc., that would be damaged by impact with any hard surface, must always be protected with wooden coverings bolted on.

Light sheet-metal work is invariably crated or boxed. The liability to damage in handling determines the amount of protection necessary. See Figs. 140, 144 and 147.

Large and **heavy** pieces of **machinery,** such as Corliss engine frames, crank-shafts, etc., need only have their wearing surfaces and fragile parts

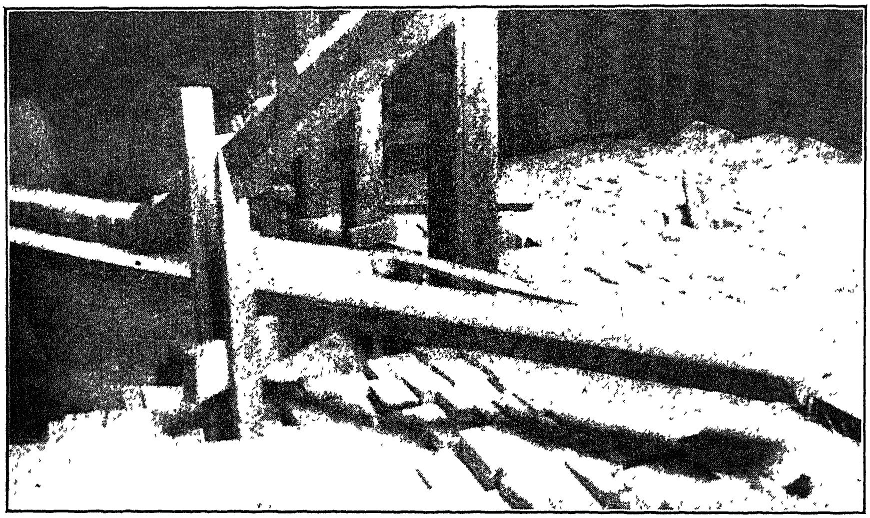


FIG. 150.—Hold of schooner shown in Fig 149; note bottom of chute and method of stowing the brick. The breakage on this shipment was practically nil.

protected or boxed, and the whole placed on skids so that the piece may be rolled into place after delivery at the factory site (see Fig. 148).

Structural Material is "knocked-down" for export shipment to a much greater extent than for domestic. Trusses (except the very smallest) are not shipped in two or three pieces, but with all their web-members loose, and chords and webs are wired together in bundles of convenient weight and size; sometimes the gusset-plates also are shipped loose. Similarly large projecting plates on columns, etc., are shipped loose, and even large and heavy bases may be designed for field-riveting. The whole idea is to reduce the cubical contents of the shipment, and also to guard against damage to outstanding material in the handling. For this reason,

for instance, the splice of a long plate-girder to be shipped in pieces must be designed so that the ends are flush, *i.e.*, with no projecting flange angles or plates that could get bent in shipment. It must be remembered that structural material, unless specially designed, is peculiarly liable to damage in shipment. How far to go in the matter of "knocking-down" structural steel for export shipment will depend upon the relative values to be attached to the shop cost, freight bill, cost of field erection, and liability to damage in shipment, for each particular case.

Considering particular cases: small tie-rods and sag-rods should be crated, wiring tends to come loose and the bundle may become scattered. Small gusset-plates may be wired together but larger ones should be bolted. Slender members, such as light truss chords, should be shipped in lengths not to exceed 25 ft., 15 ft. for very thin material; they always

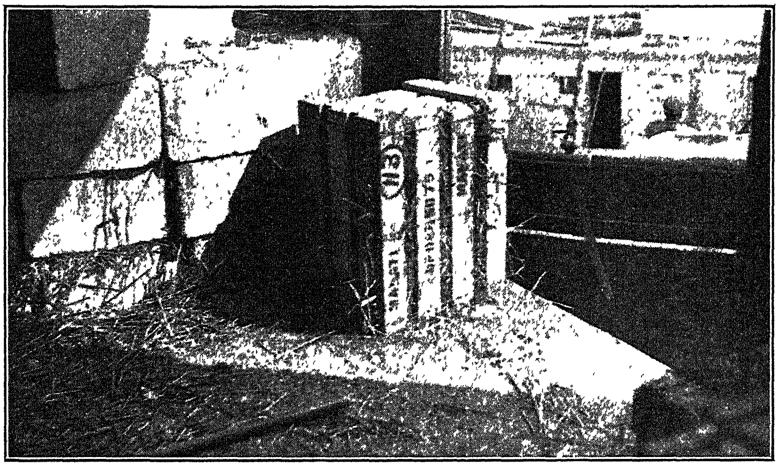


FIG. 151.—Special firebrick shapes crated for export; package 16 in. × 22 in. × 32 in. packed in straw, cleats 3 1/2 in. × 3/4 in., wired; very good packing. Large pieces of regular shape were shipped loose as shown.

get bent, and in some cases the rivets may have to be removed so that the blacksmith can straighten them in the fire.

All such material as **window frames,** whether of wood or steel, must be substantially crated, as many frames being in a package as will make a crate strong enough to ship safely.

Corrugated sheets are nested into bundles weighing from 50 to about 250 lb., the whole being either substantially wired or crated.

When machinery, etc., is entirely boxed for export shipment, provision may be made for **customs officer's inspection** by leaving a hole in the side of the case about 10 or 12 in. square and covering it with a metal plate screwed on and marked as follows: "Custom House Officer Open Here, Remove the Screws."

Firebrick for export shipment was formerly invariably crated, the steamship companies refusing to accept it "in bulk." This crating increases the cost of the brick by about one-third. Nowadays, however, it is usually accepted in bulk, although it will be sometimes refused in this condition in cases where it has to be delivered on the cars of a railroad company at the port of entry, *i.e.*, when the owner does not take delivery alongside steamer. On large consignments it usually pays to ship by schooner (see Figs. 149 and 150).

Large or special shapes, however, must be crated (see Fig. 151), and, in cases where the final transportation is by mule-back, the bricks must be packed in barrels or crates of not more than 150 lb. gross weight each, so that they may be slung on each side of the mule.

Fireclay is best packed in sacks to weigh about 150 lb. each.

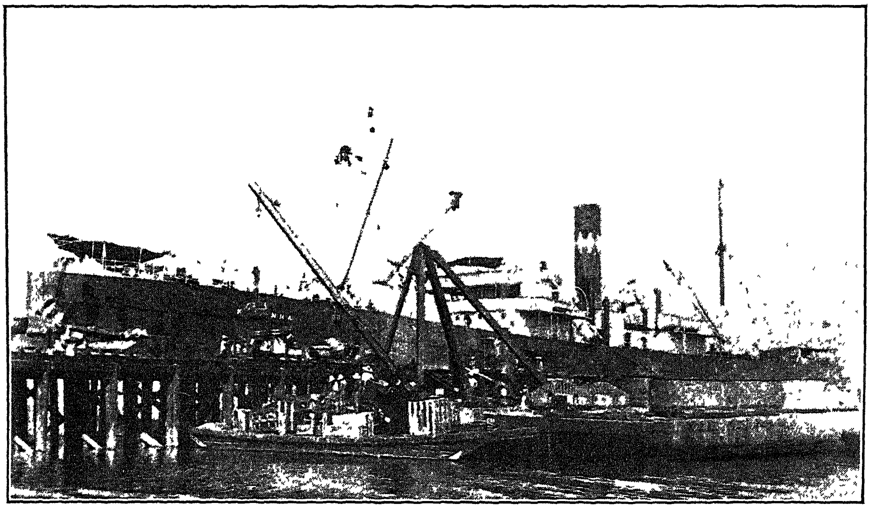


Fig. 152.—Unloading heavy machinery on to lighters and to wharf in an isolated harbor in the Philippine Islands. The steamship's "heavy lift" boom (see p. 375) is clearly shown.

Glass, both plain and wire, requires particular care in packing for export shipment; numerous reports of 60 percent to 80 percent breakage on shipments to the Far East have come to the writer's attention. The following method of packing, however, has been found satisfactory, resulting in very little breakage. Pack in a box in the best manner for domestic shipment, and then pack this box in a larger one so that a space of about 3 in. is left all around which is to be filled with hay or straw. The outer box is to be made of at least 1-in. lumber and strapped with iron bands.

Figs. 131 and 132 are examples of crates used by the Trussed Concrete

Steel Co. for export shipments of **reinforcing metal and steel sash** respectively. The first cut illustrates exceptionally good packing; the tarred waterproof felt is, perhaps, a refinement for the class of material in question, but would be essential for light machinery shipments. The second cut is typical of good packing for such articles as steel window sash.

CHAPTER X

PROGRESS CHARTS, SCHEDULING SYSTEMS, ETC.

Introduction

In this chapter are given representative examples of charts or figures for exemplifying graphically, scheduled performances, costs, progress of work, etc., etc., in connection with engineering work. It is hardly necessary to state that the graphical method of illustrating such data is, to the man of engineering training (and to the great majority of non-technical men also), very much superior to an array of figures, or pages of written matter. It is, perhaps, also hardly necessary to repeat the fact that the charts used by one company can never successfully be appropriated "holus bolus" by another; the system used must always be modified according to results desired, conditions of working, the personal equation, etc., of the second party; in other words, the whole value of those published lies in their suggestive possibilities.

Progress Chart for the Drawing Office

Practically all drawing-office work is done under the compulsion of a time limit, frequently a very short one. A power plant has to be in operation at a certain date, or machinery has to be designed and fabricated in time to catch a certain steamer, and it is necessary that drawings be prepared, and orders placed sufficiently in advance of these dates, so that promises may be fulfilled. In a small office, where only one or two jobs are carried through at one time, there may be little trouble in meeting such dates; but in larger offices, handling a dozen or more jobs at one time, some system of advance planning is imperative.

One of the most usual methods of scheduling work, not only in the draughting room but also in other departments, is by the use of chronologically divided charts.

A so-called **"Progress Chart"** that has been tested-out for several years in the office of a firm of consulting and contracting engineers engaged on export work, and which has proven itself satisfactory, is shown in Fig. 153.

The key at the top of the chart explains the meaning of the symbols, and the chronological division by (approximate) weeks is apparent.

The **method of working** consists in first of all making out a list of the main items of machinery or work and placing them in some convenient

order in the left-hand column of the sheet. Then, using **red ink** or a **red pencil,** the shipping date for each item is indicated on the chart by the letter "S" in the case of material, or "d" in the case of drawings. Knowing from past records the probable time required to obtain delivery, the

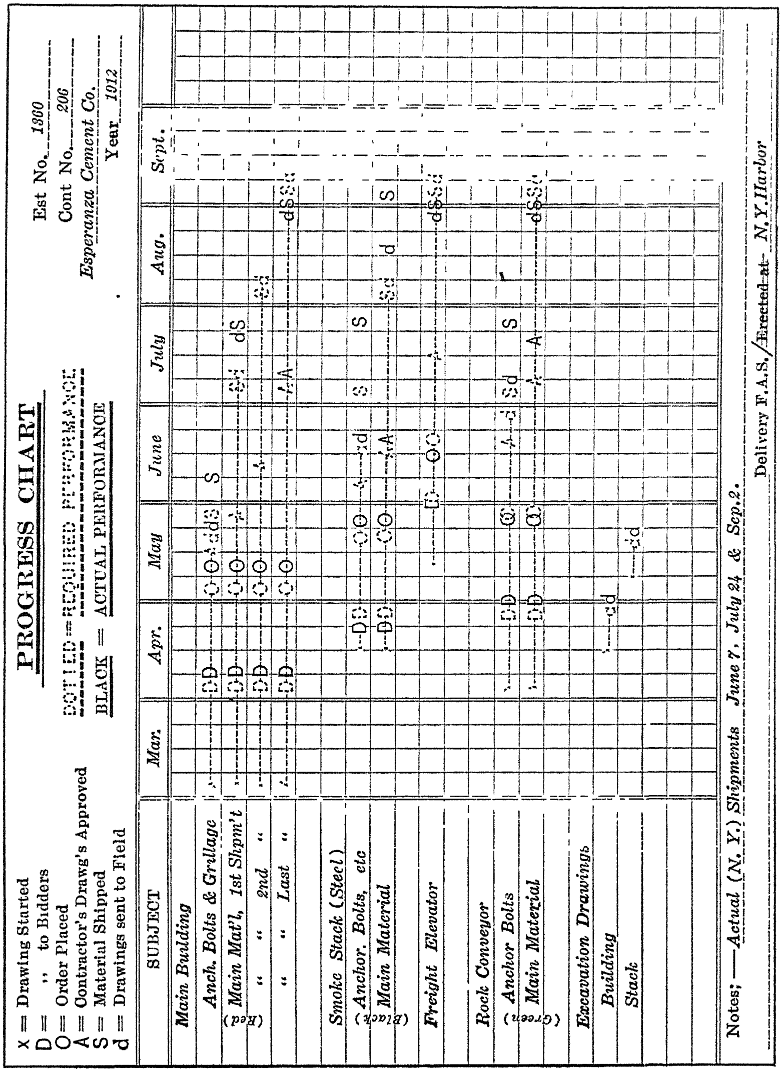


FIG. 153.—Progress chart for drawing office work.

letter "O," indicating date at which order must be placed, is next located in red a corresponding time before the "S." If it will take 2 weeks or a month to obtain bids and place an order after the drawings and specifications leave the office, the date at which they should be sent out can thus be indicated by a red "D" sufficiently in advance of the "O."

Finally, the date at which it will be necessary to start such drawings can be indicated by a red "X." Red lines should then be drawn connecting the "X" with the "D" in order that the "vital period" may be more forcibly expressed.

An **inspection of the chart** thus prepared will show the chief draftsman at a glance the magnitude of the work ahead of him. Any large bunching of red lines at one period will point to a probable required enlargement of the drawing-office force for that time. Or again, if the regular force is larger than necessary for the indications at the first stages of the work, the "X," "D" and "O" for certain items may be advanced in time, with the double advantage that the office work may be more

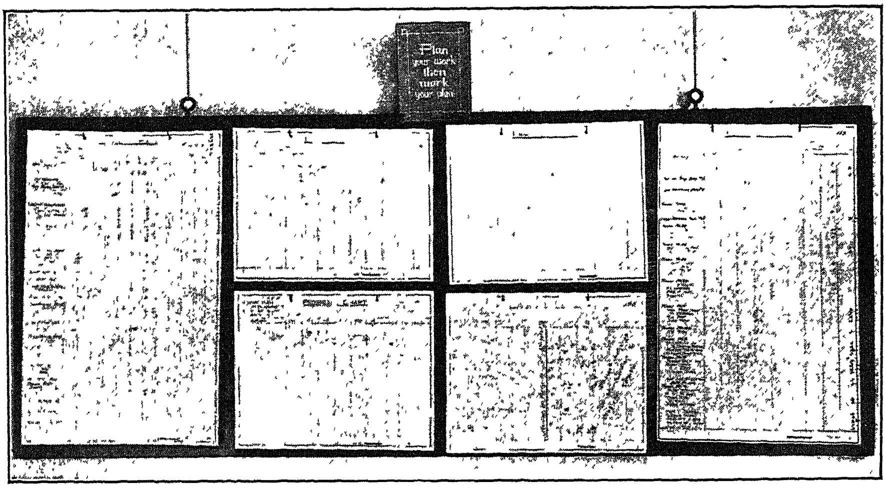


Fig. 154.—Display board for drawing office progress charts.

evenly distributed, and that better terms may be obtained from the manufacturers consequent on the delayed delivery conceded. A further advantage is the guarantee afforded against forgetting any item of importance in the installation.

In practice, of course, many conditions will arise to alter the **ideal schedule;** sickness, delayed information, strikes, etc., cannot well be foreseen, but these uncertainties are not sufficiently great to counteract in any large degree the value of the schedule.

Continuing the subject of the **method of working:** As the drawings are sent out and orders placed, these events may be noted by the marks "D" and "O" in **black ink** at the proper place in the chart. At the time that the black "O" is marked, the letters "A" (contractor's drawings approved) and "d" (drawings to the field) should be placed in red. These letters in black show that this part of the work has been disposed

of, and they are also valuable, for future schedule planning, in indicating the time that was actually required to do the work.

At convenient intervals, say once a week, the chief draftsman, by running down the list, may inform himself of the progress of the job and may make notes and issue orders to hurry along any part that may be falling behind the schedule. A pencil check-mark at the head of the list may be used to indicate when such inspection was made. When the material has been shipped and drawings sent to the works (indicated by black "S" and "d"), a blue check-mark at the end of the line will show that the work on that item is closed.

Now taking up the **mechanical features** of the system: The charts may be prepared either on stout "white mounting boards," on paper or on tracing cloth; the latter is useful when copies are required at intervals, but the former is usually preferable, and photo-reproductions may be made of the boards if necessary. The sheets may be about 14 in. wide × 11 in. high for small jobs, and 22 in. high for larger jobs, and several sheets for one job may be used if necessary. It is often advantageous to hang the sheets in such a manner that they may be readily visible from the office chair. A convenient method of so displaying the charts is shown in Fig. 154. The board illustrated is 2 ft. × 5 ft. in size, 3/4 in. thick, made of white wood with matched end-pieces, finished all over and shellacked. The charts are hung on small hooks, so that they can be readily removed. The board can be hung from the picture-molding by wire and screw-eyes.

The Scheduling System of a Large Locomotive Works

The following description is taken from an article on "The Drafting-room System of the American Locomotive Co." by Mr. Fred. H. Moody in "Machinery" for June, 1911. It illustrates very clearly the methods employed by a large manufacturing establishment in turning out its contracts on scheduled time.

"While the specifications are being compiled, the process of scheduling the work is under way. The contract specification usually states a time delivery for the locomotives. The form for scheduling is shown in Fig. 155, which shows the **schedule card for the locomotive** on an 80-day basis; similar cards are made out for the tender. On this schedule form complete information is given, but the principal feature to be noted, however, is the scheduling. All the productive work is divided into three general groups: "A," material and specifications; "B," new and old patterns and flanging dies; and "C," cards and sketches.

"A little consideration will make it clear that different lengths of time are required for making any particular part, depending upon such factors as the amount of machine work, whether it is purchased on the outside, and other equally important considerations. From long experience the company has been able to

form a general schedule showing how long previous to the delivery date it is necessary to have the different details ready. This has been prepared in the department for various delivery periods, ranging from 105 down to 40 days, the former length of time being generally required for new designs, while a repetition

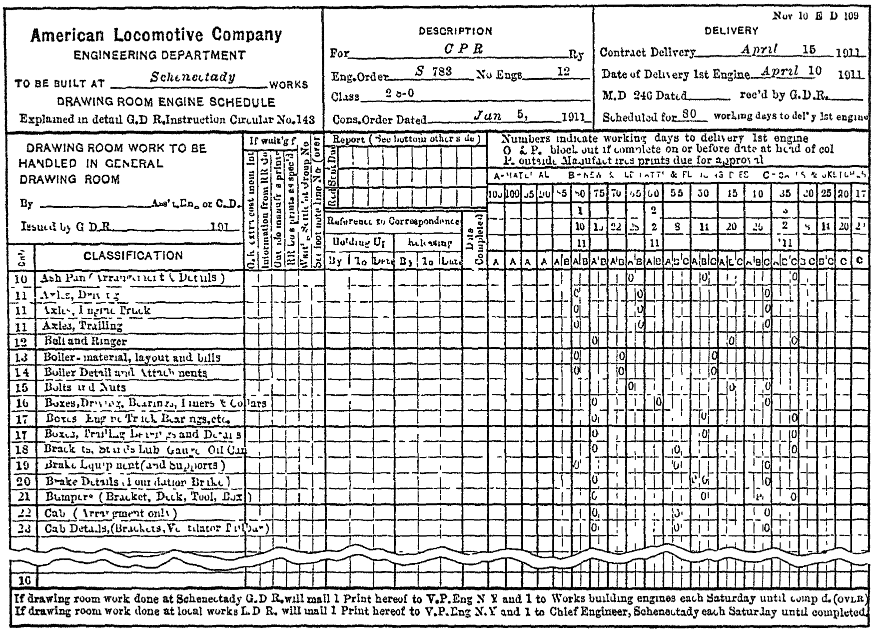


FIG. 155.—General schedule of engine for the drafting room.

order may be completed within the latter time period, from the fact that in the latter case all drawings, patterns, etc., are ready. Consider an 80-day delivery: From this general schedule the engineer knows just how much time any part requires; from a computing calendar a date for any number of working days ahead

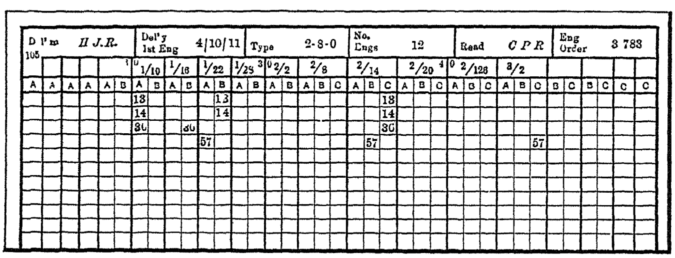


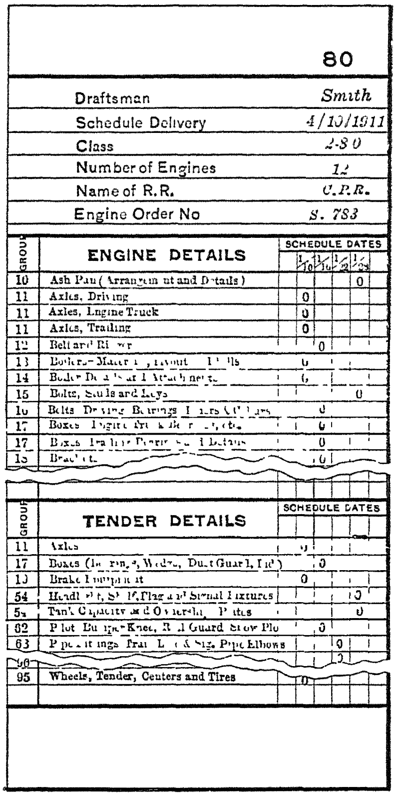
FIG. 156.—Minor schedule card for section use (Am. Loco. Co's. Drawing Office).

can be readily determined. Take, for example, "axles" on an 80-day basis; the material for these must be ordered among the first things. This is shown by the cipher opposite "axles" under list "A" of the 80-day column. The date is placed in the vacant space just above, under the squares containing "75, 70, 65,

60, etc.;" these dates are 5, 10, 15, and 20 working days ahead. It will be noticed that the dies for this order on the axles are required on the date set at 65. All cards and sketches must be gotten out on the date corresponding to 40 days. This schedule is kept by the scheduling department, which keeps in touch with all the other departments and sees that the schedule is lived up to. When the allotted time elapses, if the schedule is broken, inquiries are set on foot to ascertain the cause of the delay. When notification of the completion of each of the scheduled events occurs, the square is blocked out; the unblocked squares are the ones to be watched.

"**Minor cards,** such as are shown in Fig. 156, are made up for distribution **to the different drawing departments.** For example, the one shown is given to the section getting out groups 13, 14, 36, and 57. It shows the day on which their work is expected, and that department is held responsible should the order fall behind on that date. These are usually dated a day or more ahead, in order to give that department time to transfer the drawings, etc., to the next.

"Long cards, 22 in. in length, sections of which are shown in Fig. 157, are given to the **material department,** a separate strip for each order. When each part is completed, as with the other cards, the space is blocked out. The unblocked spaces on the date for which it is specified are then followed up to ascertain the cause of the delay. The work in all departments is therefore automatically kept moving through at the proper rate."



80

Draftsman	Smith
Schedule Delivery	4/10/1911
Class	2-8 0
Number of Engines	12
Name of R.R.	C.P.R.
Engine Order No	S. 783

GROUP	ENGINE DETAILS	SCHEDULE DATES	1/10	1/16	1/22	1/28	
10	Ash Pan (Arrangement and Details)					0	
11	Axles, Driving		0				
11	Axles, Engine Truck		0				
11	Axles, Trailing		0				
12	Bell and Ri[illegible]r			0			
13	Boilers—Mater[illegible], [illegible]		0				
14	Boiler [illegible] Attachments		0				
15	Bolts, Studs and Keys					0	
16	Bolts [illegible]			0			
17	Boxes [illegible], etc.			0			
17	Boxes [illegible]			0			
18	Bra[illegible]			0			

GROUP	TENDER DETAILS	SCHEDULE DATES					
11	Axles		0				
17	Boxes ([illegible], Wedge, Dust Guard, Lid)			0			
19	Brake Equipment		0				
54	Headl[illegible], Flag and Signal Fixtures					0	
55	Tank Capacity and O[illegible] Plates					0	
62	Pilot [illegible] Knee, R[illegible] Guard Snow Plo			0			
63	P[illegible] & Sig. Pipe Elbows				0		
90					0		
95	Wheels, Tender, Centers and Tires		0				

FIG. 157.—Schedule for material department (Am. Loco. Co.).

THE SCHEDULING AND RECORDING SYSTEM OF A LARGE CONSTRUCTION COMPANY

In the "Engineering Record" for Jan. 30, 1909 is an article (taken from the "Armour Engineer" for Jan., 1909) on some of the methods employed by the Stone & Webster Engineering Corporation, of Boston, in systematizing its field work so as to enable the home office to keep in constant touch with widely scattered jobs.

The following paragraphs embody the salient and suggestive points of the discussion.

The **superintendent of construction** on a job will have a certain organization of his own, large or small as the conditions may warrant, and he

will be empowered to do a certain amount of purchasing, sub-contracting, etc. The object of the system is, by the use of suitable charts, schedules, etc., to make plain, both to him and to the home office such matters as (1) what plans, bills of material, etc., are to be made by each; (2) what purchasing will be handled by the home office and what by him; (3) what work will be done by a contractor and what by the owner or his own force; (4) dates promised for delivery of material or completion of sub-contracts; and (5) the scheme of cost-accounting to be used on the job.

The first three items and the matter of scheduled performance of sub-contractors is epitomized in a "Working Schedule"; the delivery of material to the account of the superintendent is planned and recorded by a "Delivery Schedule"; a "Progress Report" shows scheduled and actual performances; a suitable cost-data system keeps the superintendent and the home office informed regarding unit costs, total cost as compared with estimated, etc.; and an "Organization Chart" shows graphically the extent, organization and relative authority of the working force.

The **"Working Schedule"** is made on tracing cloth, changes or additions being made as desired, and revised prints sent to the superintendent every week.

"It has a number of vertical columns in which, by the use of letters designating the engineering department, the local construction department and the sub-contractor, the source of the plans, specifications and bills of material for any particular part of the job in hand is indicated. By the use of the same letters in other columns the parties responsible for the purchase and installation or erection of the materials for each part of the job are indicated. Still other columns give the order or contract number for each part of the job, the date when the factory shipment is promised, and the dates of delivery and erection promised.

"This schedule is sent to the superintendent in duplicate, and each week he returns one copy of the old schedule with the letters corresponding to completed work cancelled thereon. The system is found to eliminate a large amount of letter writing, lost motion, and uncertainty as to responsibility for the various details of the work.

"The **'Delivery Schedule'** is corrected and forwarded to the superintendent once a month or once a week as the job may require. This schedule gives the contract or order number, shipper's name, material, original date of factory delivery, revised date of factory delivery, and dates of partial shipment for all unfilled orders originating in the home office of the work. The schedule is made in triplicate, one copy going to the construction department where a watchful eye is kept on the delivery of material, and two copies going to the superintendent, who returns one copy to the purchasing department with any changes he desires noted in a column left for the purpose and headed "Delivery Desired." The purchasing department will then apply special pressure to the shippers of these items.

"**Progress reports** are made graphically. The home office prints on tracing cloth a list of the items on which progress is to be reported. These items are arranged one under the other, and to the right are a series of columns, four for each month. The original estimate of the time taken to finish the work is indi-

cated by a horizontal blue line extending to the right to the vertical column representing the day of the month of the estimated completion. The percentage of work done at the time of the report is shown by a black line above the blue line. The actual time spent and the revised estimate of the time of completion is shown by a red line below the blue line." "By simply drawing two straight lines, one black and one red, the superintendent tells how much he has done since the last report, how much in all and how long he has been in doing it, how much remains to be done and how long it will take to do it. There are, of course, a multitude of forms that such a chart may follow, and the element of cost as compared to the estimate can be combined without greatly complicating it." (See Figs. 153, 162 and 163; Auth.)

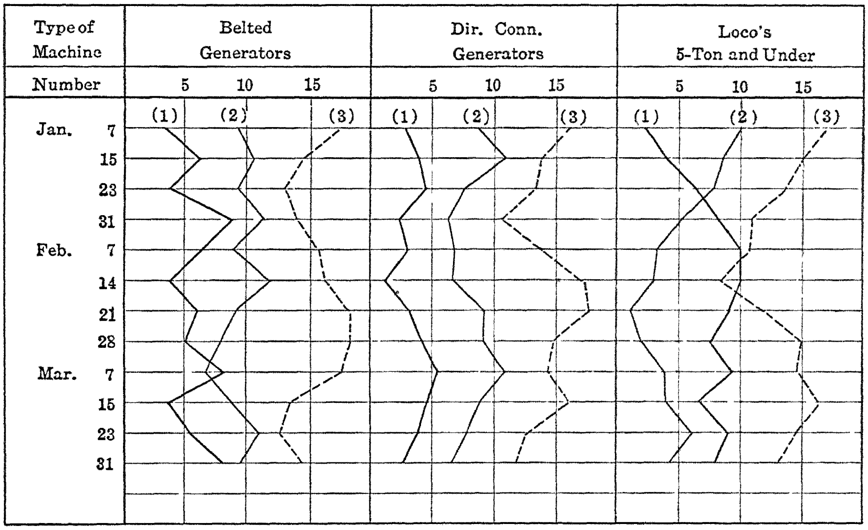


FIG. 158.—Chart for showing condition of manufacturing orders: (1) Orders received; (2) orders shipped; (3) orders in production.

An **"Organization Chart"** (presumably of the "family-tree" type, Auth.) is required of the superintendent as soon as his force is organized, and revised copies at proper intervals. This chart has the following advantages: (1) It compels the superintendent to justify the existence of his principal assistants; (2) it calls his attention to desirable increases or decreases in the size of the force; (3) it "shows the men to whom they are responsible and so eliminates disputes as to authority;" (4) it enables the construction department to detect faulty organization-methods or to make helpful suggestions, and (5) it has "the moral effect on the superintendent of putting his line-up on paper, with the consequent clarifying of his own ideas," the copy posted in the office staring him in the face every time he goes in.

The subject of **cost keeping** in general is discussed in the article, but neither the plan nor details of the system employed are indicated.

A Graphic Comparison of the Condition of Manufacturing Orders

The chart shown in Fig. 158 is adapted from "Factory Organization and Administration" by Hugo Diemer (McGraw-Hill Book Co., N. Y.). The method of compiling it is apparent. One of its principal uses consists in its ability to show at a glance the relation of the number of articles in stock or in production to the number of orders received. Should the latter (shown by the No. 1 line) approach closely or overlap the number in production (shown by the No. 3 line), a speeding-up in the manufacture of the particular machine would be indicated as being probably desirable.

A Graphic Monthly Comparison of Manufacturing Costs

The chart illustrated by Fig. 159 is adapted from Hugo Diemer's "Factory Organization and Administration" (McGraw-Hill Book Co., Inc.). The method of its compilation is apparent. In using it, it will

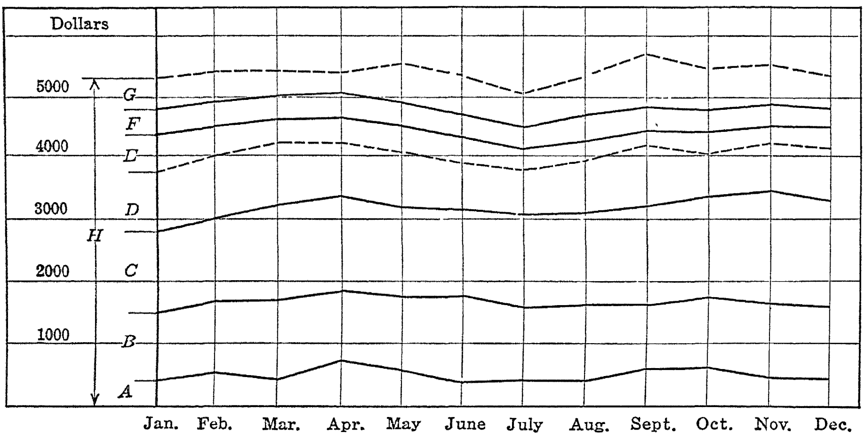


Fig. 159.—Chart showing monthly comparison of manufacturing costs.

A = Supervision and Clerical Labor.
B = Unskilled Labor per Monthly Pay-rolls.
C = Skilled Labor per Monthly Pay-rolls.
D = Materials Used in Month's Production.
E = Expense of Materials for Office, Shop Operation and Maintenance.
F = Fixed Charges.
G = Estimated Profit between Shop Cost and Estimated Value.
H = Estimating Dept's Valuation on Month's Product.

be seen that the "labor and material costs are compared graphically with the estimated value of the product" and that "so long as the area underneath the sixth line does not project above the seventh line there is a probability of a profit."

In common with other charts of this character, it also serves to point at once to any increase in the costs of any particular department or expense item. Such increase may, therefore, be made the subject of immediate investigation. The same comparison can, of course, be made by tables of figures, but, in most cases, in not such a convenient and striking manner.

A Progress Chart for Concrete Bridge Construction

An article on "Office System for Construction Work" in "Eng.-Contr." for Dec. 17, 1913, is referred to below; see p. 404. In this is given, also, a progress chart for a concrete bridge construction which is reproduced in Fig. 160. The method of developing it is apparent. One of its valuable features is its use "in connection with the cost data, as

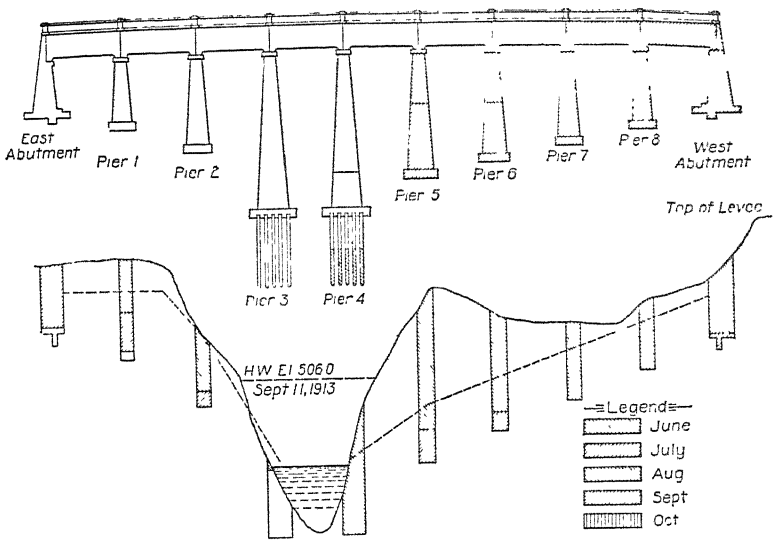


Fig. 160.—Specimen progress elevation and profile of a bridge.

it explains many things regarding unusual unit costs for any particular month."

A Progress Chart for Track Reconstruction

In the "Eng. News" of Sept. 26, 1912, is shown such a chart, reproduced in Fig. 161. It was prepared by the street railway company to ensure restoration of street service within the time granted by the Board of Public Works at Vancouver, B. C. A little study of the chart will render its utility clear; modifications, such as separate charts for each operation, and a system of colored marks to show the relation of the "work performed" to the "work planned" will also be suggested.

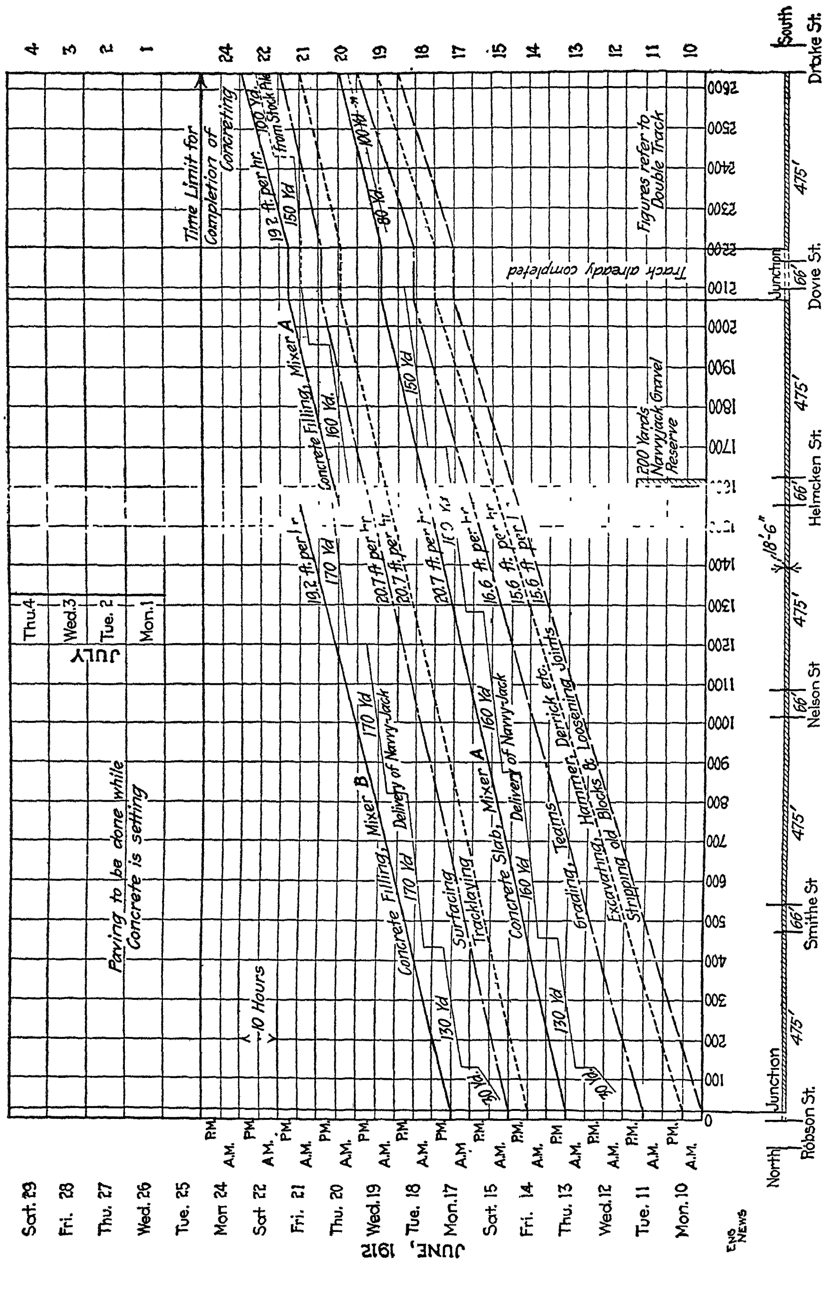


FIG. 161.—Progress chart for track reconstruction; prepared in advance to ensure the completion of the work within a specified time. (Horizontal spaces from June 10 to 24 are ten-hour shifts.)

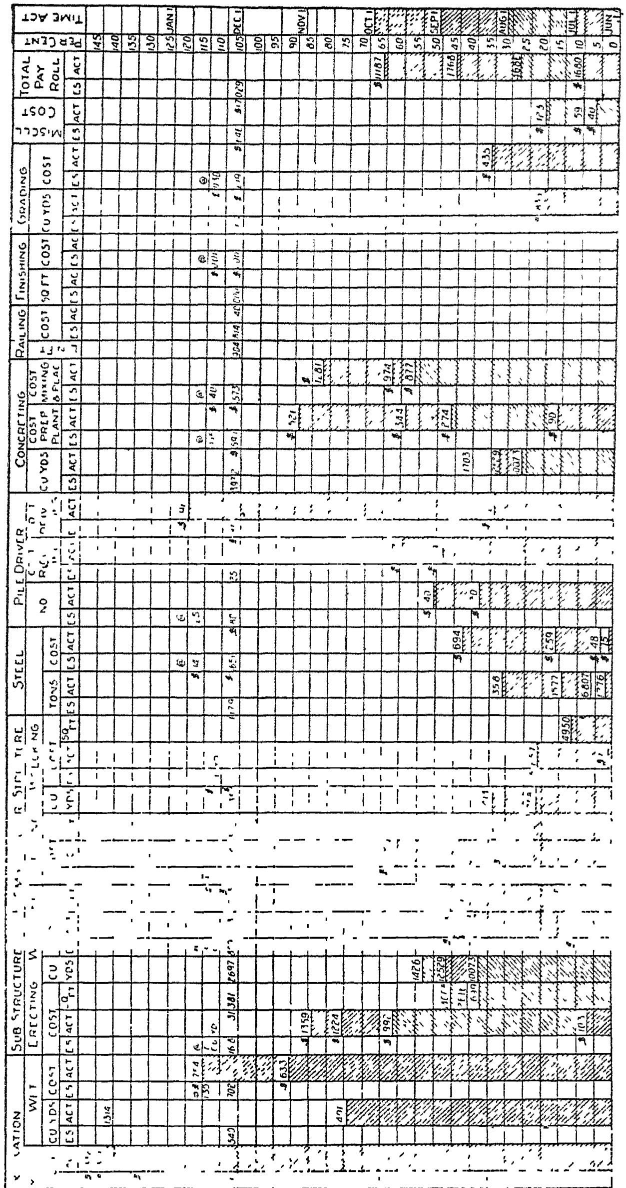


FIG. 162.—Chart showing expenditure for labor on construction job.

A Combination Cost and Progress Chart

In "Engineering-Contracting" for Dec. 17, 1913, is an article by Mr. E. W. Robinson entitled "An Office System for Construction Work Covering Records of Plans, Progress and Cost and Bookkeeping Methods," which is a very clear and suggestive exposition of this subject. A system

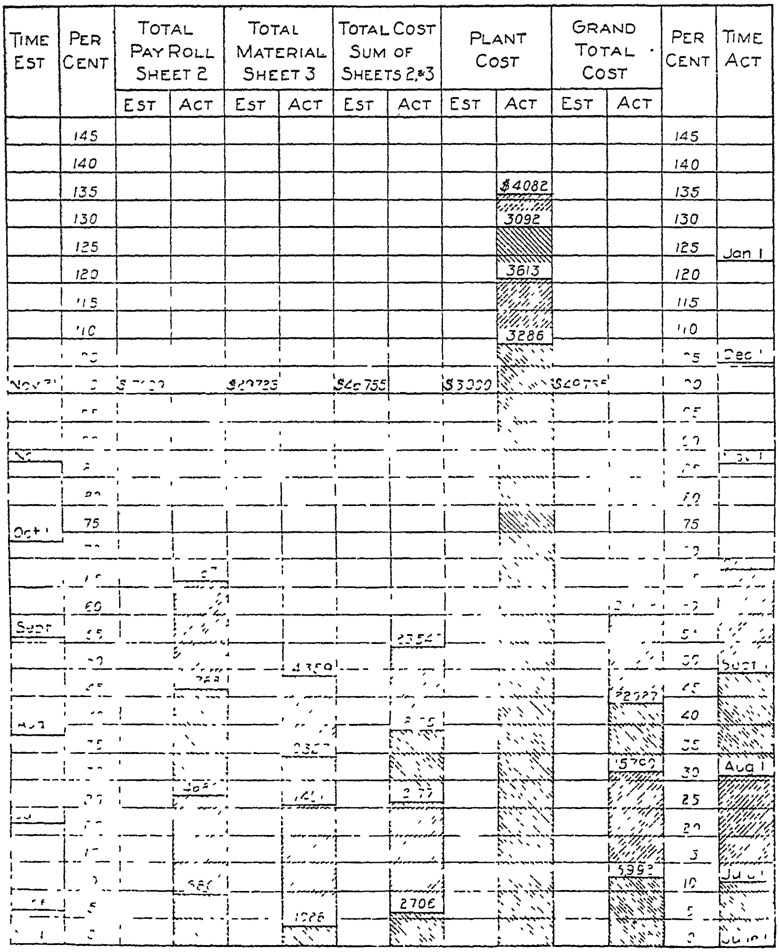


Fig. 163.—Chart giving summary of labor and material expenditure and plant cost on construction job.

of chart-making which illustrates itemized expenditures to date, the unit costs of the same, the amount and percentage completed of each class of construction and for the job as a whole, will alone be considered in this section.

For a typical concrete construction job, three progress charts are made

out; one to cover labor costs only, one showing expenditure for materials and other accounts, and a third giving a summary of the other two: only the first and third are reproduced here, the second being shown in Fig. 92 (Chap. VI).

As shown in these figures, the charts "consist of parallel vertical columns which are filled with the particular kind of cross-hatching for the month in which the work was done. About two-thirds the way up from the bottom a heavy horizontal line is drawn through the columns to represent the estimated quantities and costs, or 100 percent. This line also represents the time for completion as shown in the contract. Then, if there is estimated to be 1,000 cu. yd. of concrete to be poured, and the total time for completing the job is 4 months, if at the end of the second month there are only 250 cu. yd. in place, the cross-hatching in the quantity column under the heading of "concrete" will be advanced from where it was the previous month to a point 25 percent from the bottom line of the chart, while in the time column the same style of cross-hatching will be advanced to a point 50 percent from the bottom. This will show, for that particular item, that we are only 25 percent completed, when to finish according to schedule time we should be 50 percent completed. On a large job with many items of nearly equal importance, it requires judgment to state the stage of the work from these charts, for the reason that when our time is 50 percent gone several items may be 99 percent completed and others only 5 percent and the relative importance of the different items must be taken into account. The principal value of the charts, however, is in showing the unit costs from month to month, and their variation according to quantities, locations, weather, etc. The same variation in regard to cost may exist as in regard to time. That is, several items may run 200 percent or even more above the estimated cost for that item, and yet the job as a whole be completed below the estimate. If the unit costs as a whole are running close to the estimated costs, then the total actual cost column, when compared with the time column, shows a fairly accurate representation of the rate of progress.

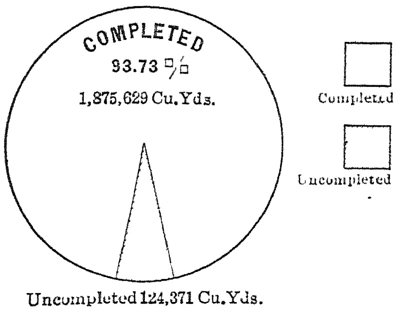


FIG. 164.—"Clock chart" method of illustrating percentage of work completed (on Gatun locks).

"The unit costs for each month are written in small figures in the total cost column.

"The third chart (Fig. 163) is merely a summary of the first two, together with the plant expense chargeable to that job. The first cost, in the case of new equipment, and the invoiced value in the case of second-hand equipment, is charged directly to each job, as it is placed on the work. Then the sale price, if sold, or the invoiced value if moved to another job, is given as a credit, leaving the balance as the depreciation or cost of plant for that job."

The "Clock Chart" Method of Illustrating Percentages

This method is particularly adapted to illustrate reports, etc., intended for non-technical readers, and to show succinctly the relation of complex figures to one another in technical articles.

Fig. 164 is taken from one of the charts issued by the Isthmian Canal Commission to illustrate the progress of the work on the Gatun Locks. A diagram of the lock shows the uncompleted parts in hatched lines, and the clock chart shows at a glance the percentage completed.

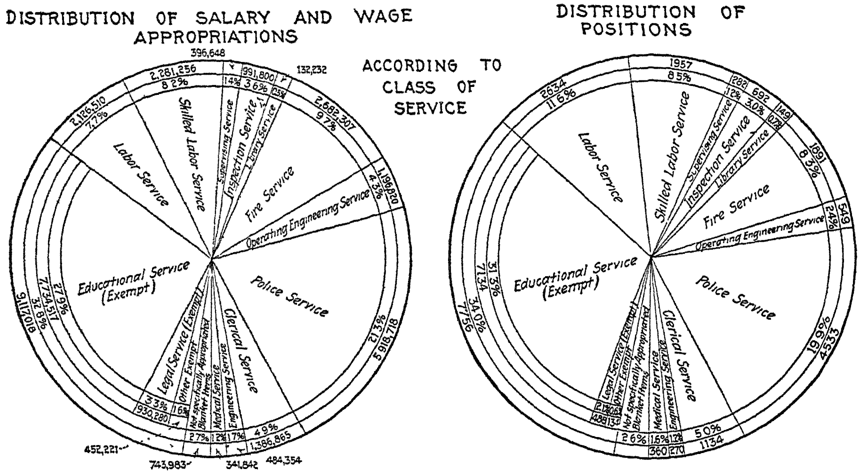


Fig. 165.—"Clock chart" method of illustrating the relative compensation and classification, etc., of the employees of the city of Chicago.

Fig. 165 is taken from a report of the Civil Service Commission of Chicago on the compensation and classification of the employees of the City of Chicago. (Eng. News, May 2, 1912.)

The charts are suitable for placing before a board of non-technical men, and, with appropriate explanations, would serve to carry home to them points which mere tables of figures and percentages would never do.

CHAPTER XI

INDEXING AND FILING SYSTEMS, ETC., FOR THE ENGINEERING OFFICE

SEC. I. GENERAL ORGANIZATION SYSTEMS

A Schedule for the Maintenance of Records in a Small Engineering Office

The following schedule outlines in tabular form a typical scheme of filing, indexing and recording the movement of the data in a small engineering office. In larger offices the scheme will usually be the same, although methods will be more elaborate than those indicated below.

Item	Filed	Indexed	Movement record
Correspondence	*General Office File* (originals) Outgoing Mail (1) Alphabetically (name of addressee) (2) Date Incoming Mail· (1) Alphabetically (name of addresser) (2) Date *Department Files* (copies) Outgoing and Incoming Topically, or by Date	Outgoing Mail By consecutive numbers Incoming Mail; Not indexed	Outgoing Mail: In consecutive number book, date, addressee, etc. Incoming Mail: Not recorded
Estimates	By consecutive number, in folders	In consecutive numbered "estimate book," giving title, name of client, date, record of data, and final disposal of Est. Note.—Alternate estimates can be indexed by suffix A, B, etc., to original number (see p. 230) Also "Estimates" and "Contracts" should be card-indexed under headings "Client" and "Subject" (see p 232).	By check mark or date in "Estimate Book."
Cost Data	In loose-leaf books, typewritten on a uniform system (see p 229).	Loose-leaves self-indexing on an "extended alphabetical" (see p. 414) or other system.	
Contract Data	In some type of "invoice" size file This may include the correspondence, memoranda, specifications, shipping lists, etc , and finally, the record sheets (see p. 473). File to bear the contract No., and to be alphabetically partitioned.	In consecutively numbered "Contract-Book," giving Title, Name of Client, Date, Record of Preliminary Data, and brief Progress Record Also card indexed as per "Estimates."	On "Progress Chart" (see p. 393).

Item	Filed	Indexed	Movement record
Field Books	By consecutive number; or, (for loose-leaf books), topically or in Contract File.	In consecutively numbered "Field Book Record" giving Date, Name of Recorder, etc, to suit the class of work	
Computations	All computations to be made in books, loose sheets to be pasted in Books to be numbered consecutively, and so filed. (See p 489) Or (for loose-leaf books), topically or in Contract File.	In consecutively numbered "Computation Book Record" giving Dates (begun and finished), Name of Computer, and Table of Contents (see p 489).	
Memoranda, Reports and Sketches	In "Contract Data" file Sketches regarded as correspondence	Self-indexing by "Job No," or job and topic number, etc (see p 488).	All memoranda etc, to be addressed and dated, and copies placed in file, so as to be self-recording
Photos	In "Contract Data" file, or pasted in loose-leaf book.	File so as to be self-indexing, or use any of the usual methods of indexing that may be best adapted to the case (see p. 491).	Treat as correspondence, or record same as blue-print
Tracings	By "Job No," topically, size, etc (see p 458 *et seq*, for various methods)	By consecutive number, or job and sheet number, or topic and sheet number, etc (see p 458 *et seq* for various methods) For Revisions see p 504	None, or by requisition slip
"Original" Blueprints	"Record" prints filed by "Job No," topically, by size, etc	Self-indexing by "Job No," or job and topic number, etc. (see p 468).	On record sheet as shown on p 475, or similar.
"Outsider's" Blueprints	With correspondence, by "Job No," topically, etc (see p 468).	By "Job No," or job and topic number, etc (see p 468).	Treat as correspondence, or record as shown on p 475 or similar
Specifications	In "Contract Data" file	By consecutive number, or by job and specification number, etc	On record sheet as shown on p 477, or similar
Shipping Lists or Invoices	In "Contract Data" or separate S/L file	Numerically, topically, etc	On record sheet as shown on p 477, or similar.
Catalogues	By size, topically, by firm name, etc, with a consecutive number or a decimal system of numbering (see p. 492).	By firm name, by topic, or by both.	None, or by requisition slip.

The system is presented more particularly, however, to the "three or four-man" organization which has good prospects of growing business, as

an aid to the installing of methods that will not become over-run and disorganized by the mass of data that accumulates in time, or by the increasing amount of material to be handled every day. The various methods referred to are taken up in greater detail in other portions of this book.

A Method of Indexing and Filing Engineering Office Records Under a Uniform System

In the schedule for filing and indexing the various data of an engineering office given in the preceding article, a separate system of filing and indexing is often indicated, depending on whether the data is contained in a letter, a drawing, a calculation sheet, etc. Thus, letters may be filed on an alphabetical system; original tracings on a "job No." system; calculation sheets on a "Subject Classification" system, etc.; and, in the great majority of offices, this diversity of methods will be preferred.

For the purpose of showing that this method is not the only one in use, and that it is possible to install a uniform system under which *all* data may be indexed and filed, irrespective of whether it is a letter, calculation sheet, drawing, etc., so that *all* the information on one subject may be found under **one file number;** the following brief summary of the system[1] devised for the New York Board of Water Supply, by its Engineering Bureau, is included.

General Description

At the time of the organization of the Engineering Bureau of the N. Y. Board of Water Supply, the endeavor was made to select a filing system that would be uniform in all offices of the board; which would continue adequate indefinitely, which would be uniform for all classes of data, such as drawings, computations, correspondence, field notes, estimates, force accounts, etc.; which would bring together in the files *all* data bearing on one subject; and which would, at the same time, satisfy the usual requirements of compactness, ready finding, certainty in operation, economy, etc.

The system selected consisted of a numbered classification with a decimal subdivision.

The Index

The whole field of "Water-supply Engineering" was embraced under 70 or 80 headings, using "main structures" for the first eleven divisions, *e.g.*, 2 to cover Watersheds; 3 Reservoirs, 5 Aqueducts, etc.; these being supplemented by other headings relating to materials, methods and generalities, such as, 23 Concrete; 69 Inspection; 74 Surveying, etc.; (compare "The Number System of Indexing with Decimal Extension," p. 415).

[1] Eng News, Aug. 6, 1908. "The Filing System of the New York Board of Water Supply," by J. Leo Murphy

Each of these headings was subdivided under the decimal system, the division extending to two, three, four, etc., figures, depending upon the extent of the subject. The decimal system is described elsewhere in this volume (see pp. 415, 416, 438, and 442), and this part of the installation will not be described further, although the original article gives all the main headings and indicates some of the principal decimal subdivisions.

There was prepared, in addition to this "Topical Index," an "Alphabetical Index" which showed at once the index number of any subject. (See pp. 419 and 438.)

The preparation of the topical index with due regard to the relative precedence of "kinds" of structures, "types" of structures, "general data," etc., and with proper anticipation of the future demands upon it, is work calling for special talents of a high order; and the operation of the system, involving the proper fitting of the material to the index, etc., also requires supervision of scarcely less ability; so that the installation of such a system is a matter to be undertaken only after a very thorough study of the conditions presented, and only when the matter of obtaining and keeping competent manipulators is assured.

Guide Letters

In addition to the "number" given to every subject letters were used to indicate, also, (1) the "treatment," point of view or phase of the subject under consideration (compare the "Form Division" of the Dewey system), and, (2) the "locality" of the subject, identifying the structure with one particular locality, department, etc. The "treatment" letter preceded the "number" and the "locality" letter followed it.

Examples of Indexing

The following examples will best illustrate the manner of marking the data for the files.

D 5.3 C G = Design (D) of Garrison (G) tunnel (5.3) of the Catskill Aqueduct (C).
F Δ 3.0 A = Office computations on field notes (F) of triangulation (Δ) on Ashokan (A) Reservoir (3.0).
G 71.0 = Record of borings (G) on "foreign" tunnels (71.0).
E 3.4 AO = Estimate (E) on the Olive Bridge (O) dam (.4) of the Ashokan (A) reservoir (3.).

Advantages and Disadvantages

A study of the system herein described will reveal, besides its conformity with the above principles, the following advantages.

"(1) Subjects are grouped and held by the file numbers in the relation to each other that serves best the conditions of the work. Therefore, allied data will be found together in the files, and not widely scattered throughout them.

"(2) The system is rigid, inasmuch as the subjects are always in the same

relation to each other, but the decimal file numbers permit of ready coördinate expansion.

"(3) Integral numbers dispense with the necessity of limitation to ten classes, similar to those of the Dewey system, which would be impracticable where structures are concerned.

"(4) It is applicable to all classes of data.

"(5) All files are identical, so that the individual understanding files in one office can operate those in any other. Men transferred from one office to another do not have to learn a new filing system.

"(6) Data interchanged between offices does not have to have file numbers or other changes made on it; it goes into the same pigeon-hole, wherever its destination. Indexes do not have to be changed when data are moved from place to place, either in the same office or from one office to another.

"(7) The minimum filing space can always be used; a large space does not have to be allotted on a guess at future conditions.

"(8) Expansion can be made from month to month or from year to year whenever desired, without changing file numbers, indexes or other marks that locate a drawing in the files.

"(9) The result of one man's studies or investigations are made readily available to all.

"(10) The system continues good indefinitely and will not be outgrown by the business it serves."

The following may be considered disadvantages:

"(1) It is necessary to arrange the subject list long before the work. Subjects are therefore grouped rigidly in a relation that may not prove good.

"(2) Engineers must study the system so that they can arrange their work so that it can be filed readily without an undue amount of cross indexing.

"(3) The rigidity of the grouping does not lend to filing data on structures when they are studied in a different connection from what the subject list contemplated in its original design."

SEC. II. SYSTEMS AND APPLIANCES IN DETAIL

Systems and Appliances of Indexing, Filing and Recording

Definitions.—The word "system" is used so frequently in connection with business methods and appliances that its proper relation thereto is sometimes lost sight of; often to the detriment of the installation. The following definitions are intended to emphasize the distinctions.

A **system** of indexing, filing, recording, etc., consists of some prearranged plan for carrying out these operations. Thus, we have the alphabetical, numerical, geographical, topical, chronological, etc., systems for indexing and filing correspondence, drawings, etc.

Indexing consists in the installation of "pointers" to the proper location of a letter, drawing, etc., in a file. These pointers may take the form of "tabs" on the cards of a card index or on the page of a book; or of a

number on a drawing indicating its correct position in a file; or of the line of an alphabetical index placed at the end of a book. A **"system of indexing,"** therefore, is an arrangement of pointers according to some such system as is mentioned above, alphabetical, chronological, etc. An index is not a "system," it is an "appliance."

Filing is simply the manual operation of stowing away letters, drawings, etc., according to some system, alphabetical, numerical, chronological, etc.; **"finding"** being the reverse operation. The phrase **"filing system"** sometimes refers to the system according to which the material is filed, and sometimes to the appliances used.

Recording, also, is simply the manual operation of entering data in cards, books, etc., according to some system such as is mentioned above.

Appliances.—Card indexes, loose-leaf books, bound books, vertical letter-files, etc., are not "systems," they are merely the **appliances** of systems of indexing filing and recording. The systems have usually become so dependent upon the appliances, however, that the reversal of nomenclature has become general; and in the following discussion the commonly accepted phraseology has been used.

A misconception of the proper relation of the "system" and the "appliance" is, nevertheless, at the root of many of the troubles experienced with the products of superficial and incompetent "systematizers." In too many cases the efficiency of desired results is sacrificed to the installing of a favorite appliance which is unsuited to the particular conditions. The card index and the loose-leaf methods, especially, have each their special advocates, and the manufacturers of these appliances wage wordy war on one another in their respective catalogues and advertisements. The fact is that each of them, together with the "bound book" and other methods of filing information, has its own particular field of usefulness, and that the fields in many cases overlap one another. No hard and fast rules can be set down, therefore, as to when one appliance will be better than another; and, in deciding on any particular case, a number of different points have to be taken into consideration. As a guide to such choice, the endeavor has been made to outline in the following sections the prominent advantages and disadvantages of each method.

General Observations.—The indexing, filing and recording of books, drawings, data, etc., are separate and distinct functions, each calling for separate treatment. Frequently, however, any two, or all of them may be merged into one system. For example; a book comes into a library, it is indexed by a card system, filed by such some system as the Dewey decimal method, and if it leaves the library is recorded by a "dummy" put in its place or by entry in a book kept for this record; all the operations are conducted under separate systems. Again, a blueprint of an engine foundation arrives in a consulting engineer's office; it is indexed in a book giving the date of its arrival, drawing number, whom from, etc., and is

then filed under the job number; when the time comes for it to be sent to the erector, an entry of such forwardal is made opposite the record of its indexing; the indexing and recording takes place under one system. Or the print may not be indexed (pointed to) at all, and recording only taken care of by the accompanying correspondence; in this case the correspondence system of filing and recording takes care also of the drawings, for which no separate system is used.

If a counterweighted cord is attached to a rubber-stamp, the stamp will be "self-filing." If different colors of paper are used for copies of orders, etc., going to different departments, the color is an index (or "pointer") as to the proper location of the sheet, which will thus be, to a certain extent, "self-indexing." The absence of a "work order" card in the pocket of a "route rack" records at once the fact that the machine in question is not working; the system, therefore, is "self-recording" on this point.

Any such possibility of combining systems, or of making books, data, etc., "self-indexing," "self-filing" or "self-recording," providing of course, that satisfactory results are secured, is likely to effect a saving of time and work. Such simplification of systems will often be found when studied after a few months of use, and should be periodically looked for.

The Alphabetical System of Indexing

For indexing card index or loose-leaf systems the alphabetical division is one of the most largely used methods. Standard sets of tabs may be obtained for either cards or loose-leaf books, dividing the alphabet into 26, 40, 80, 120, 540, etc., etc., parts.

The system would seem to be simple, but in practice many difficulties present themselves.

As a file grows it may be found that the alphabet has not been sufficiently subdivided to allow a card to be located as quickly as desired, and a larger alphabet must be procured and the cards rearranged. When the subject of the index naturally calls for alphabetical sub-filing this may not be a very serious matter, but when the sub-filing is on some other than an alphabetical system, the cards have to be rearranged for the new tabs. Also, if more than one item appears on a single card, the whole index may have to be entirely rewritten. Care should therefore be taken when installing any such system to anticipate as far as possible the *ultimate* use and capacity of the file.

Another difficulty that is often experienced is the rapid filling-up of a few divisions. For example, a great number of references to "Chutes," "Conveyors," "Crystallizers," etc., may all fall under one tab, while many tabs may not be utilized at all, so that a larger alphabet may not relieve the condition. In this case resort may be had to "blank" tabs

on which are marked the desired headings; these tabs subdivide the alphabetical divisions as required, and facilitate quick location of the most used cards.

In general it may be said that the alphabetical system of dividing an index should be looked on with suspicion, and that unless the final growth and the utility of the file can be clearly determined in advance, some modification or some other system had better be adopted.

The Alphabetical System of Indexing With Number Extension

The following method of indexing applies more particularly to loose-leaf systems that require a larger amount of sub-indexing than the alphabetical system conveniently affords, and which, at the same time, obviates some of the difficulties of the latter.

In brief it corresponds to the alphabetical index of a book. A set of alphabetical tabs of the desired number of subdivisions is used; and, in

Boats, Power	(See Misc. Equipment)
Boilers, Fire Tube:	
Cylindrical R T	3
Loco. Type	4
Marine	5
Miscellaneous	6
Boilers, Water Tube:	7
Boiler Brichins (Uptakes)	10
Boiler Brickwork	11
Boiler Fittings (Steam and Water)	14
Boiler Furnace and Setting Irons	(See Furnaces)
Boiler Smoke Flues	(See Smoke Flues)
Boiler Supports	15
Bolt Cutters	31

Fig. 166.—Index Sheet for Alphabetical System with Number Extension.

addition, a large number of consecutively numbered tabs, 1, 2, 3, 4, etc. The alphabetical index is placed at the front or end of the file, all together; and the numbers are distributed through the file, corresponding to the pages of a book.

Under each letter-tab (usually on a loose-leaf) is given a list of the articles indexed, and opposite each is the number (or page) under which the information may be found. A sample index sheet is given in Fig. 166.

It will be seen that a far greater amount of subdividing can be obtained than with the usual type of alphabetical file. Furthermore, should it become necessary at any time to still farther split up any subject, it is only necessary to take a series of new numbers as required, alter the

index sheet, and rearrange the sheets in question under the new number-tabs. Also, should it be found necessary from time to time to rewrite any particular index sheet that may have become unwieldly, the files themselves may remain undisturbed.

As the index grows, it may be found advantageous to use a separate book for the index and as many books as required for the numbered files.

A sufficiently well subdivided alphabet should be selected in the first place, although an error in this direction is not apt to be so disastrous as in the case of the straight alphabetical system. (See p. 413.)

The above remarks apply more particularly to loose-leaf systems and to engineering office requirements; the method itself is that commonly used by bookkeepers for keeping accounts of customers, etc., in old-style bound books.

The Numerical System of Indexing With Decimal Extension

A criticism of the Dewey Decimal System of classification (p. 416) that may be made in certain cases, is that the limitation of subjects under ten headings does not allow a sufficient and proper number of primary divisions for the scope of the work. The obvious remedy is to allow an unrestricted number of primary divisions, with the use of the decimal system for the subdivisions where such a restriction is usually of no particular disadvantage. This method of classification is referred to in several places in this volume (pp. 409, 437, 442 and 495), but the following example will illustrate the matter in brief and convenient form.

If it is desired to classify the operations and products of Civil Engineering on this system, the following primary headings may be used:

1. Land Surveying.
2. Railroads.
3. Highways.
4. Bridges.
5. Buildings.
   Etc., etc.
13. Miscellaneous Structures.
14. Miscellaneous Operations.
15. Materials of Construction.
16. Appliances of Construction and Operation.
    Etc., etc.

leaving "gaps" at intervals for possible future headings. It will be seen that there is no restriction to ten classifications, and the widest amount of latitude is given to the individual requirements of the indexer.

The subdivisions of "4. Bridges" on the decimal system might be:

4 0 Bridges, General.
4.1 Sub-structures.

4 2 Railroad Superstructures (including combined R. R. and H'way).
4.3 Highway Superstructures, etc., etc. (See p. 450.)
4 9 Not otherwise listed.

In the strict decimal system, "16." would, of course, be the sixth heading under division "1" (Land Surveying); while in the "numerical system" it will be an entirely separate main heading.

The Dewey Decimal System

The following description is extracted from Bulletin No. 9 of the University of Illinois Engineering Experiment Station, by Messrs. L. P. Breckenridge and G. A. Goodenough.

Introduction

The decimal system of classification was devised and elaborated by Mr. Melvil Dewey, formerly director of the New York State Library. This system was intended primarily for the use of librarians in the classification and arrangement of books and pamphlets, but it was soon found that the system furnished also a simple and effective means of classifying, indexing and filing literary matter of all kinds. Engineers have found it useful for indexing technical data and information, catalogs, reports, card systems, drawings, etc., and it has been found equally useful by manufacturing and business concerns.

Explanation of the Decimal System

The essential characteristic of the Dewey system is its method of division and subdivision. The entire field of knowledge is divided into nine chief classes numbered by the digits from 1 to 9. Matter of too general a nature to be included in any of these classes is put into a tenth class and indicated by 0. The following are the primary classes of the Dewey system:

0. General Works	5. Natural Science
1. Philosophy	6. Useful Arts
2. Religion	7. Fine Arts
3. Sociology	8. Literature
4. Philology	9. History

Each of these classes is again divided into nine divisions, with a tenth division for general matter, and each division is separated into nine sections. The sections are again subdivided and the process may be carried as far as desired. To show clearly the working of the system the divisions of class No. 6 (useful arts) and the sections of division No. 2 of this class (engineering) are given.

600. Useful Arts (General)	620. Engineering (General)
610. Medicine	621. Mechanical
620. Engineering	622. Mining
630. Agriculture	623. Military
640. Domestic Economy	624. Bridge and Roof
650. Communication and Commerce	625. Road and Railroad

660. Chemical Technology	626. Canal
670. Manufactures	627. River and Harbor
680. Mechanic Trades	628. Sanitary Water-works:
690. Building	629. Other Branches

It will be seen that the first digit gives the class; the second, the division; and the third, the section. Thus 625 indicates section 5 (railroad engineering) of division 2 (engineering) of class 6 (useful arts). For convenience a decimal point is inserted after the section digit. Further subdivision is indicated by digits following the decimal point. For example 625.2 is the number indicating rolling stock; 625.23 passenger cars; 625.24 freight cars, etc.

Uses and Advantages of the Decimal Classification

The decimal classification may be used to advantage in the indexing and filing of notes and memoranda, clippings, general information, articles in technical journals, drawings, catalogues, and books. For this purpose the decimal system possesses certain important advantages over the alphabetical system.

(1) It groups allied subjects. For example, suppose the alphabetical arrangement to be applied to a case of catalogues. The catalogues of the various machine tools, as planers, lathes, drills, hammers, etc., would be scattered throughout the case. With the decimal system on the other hand, all these catalogues would be grouped together under the class number 621.9.

(2) Unless an elaborate system of cross reference is used, the alphabetical scheme is ambiguous; in many cases there is doubt as to what letter should be given a subject. For example, take the item, "Automatic pneumatic block signals." This might almost equally well be indexed under A,P,B. or S. With the decimal system this item has its one number 656.256.4.

(3) The decimal system has the advantage of flexibility and indefinite capacity for extension. For the indexing of books and catalogues only the main divisions and sections will, in general, be found necessary; but for card indexes of technical literature the most minute subdivisions must ordinarily be used. In individual cases, the user may find that still further division is required. An extension may then be made by adding another decimal place, and if still further subdivision is required still another digit may be used.

The average engineer, for example, can easily index all matter relating to traveling cranes under the same class number 621.872. The designer or builder of cranes may, however, have so much matter relating to this special subject, that further subdivision is needed. By the addition of a digit, this matter may be divided into nine groups designated by 621.872.1, 621.872.2, etc., and, if necessary, each of these may be divided into nine new groups.

Variations and Modifications

In the modern use of the system the main divisions and sections as published by Mr. Dewey have been retained unchanged. It cannot be denied that there are many glaring inconsistencies in the arrangement of engineering subjects. For example, no engineer of today would put Electrical Engineering as a division under Mechanical Engineering (621.3) coördinate with Blowing and Pumping

Engines (621.6) nor would he relegate concrete to an unimportant place under Building Materials. There is no doubt that a committee of competent engineers could vastly improve the logical arrangement of the class numbers for engineering subjects. However, the system as it is, with its faults, has been in use for several years and has become more or less universal. It is used in libraries and by many business concerns and individuals. It has become a sort of standard like the "Sellers" system of screw threads. For this reason alone, radical changes would be inadvisable. The inexperienced user will be likely to see room for improvement and will be tempted to make changes in the system for his individual use. Such changes can only lead to confusion. It is far better to accept the system merely as an arbitrary set of numbers corresponding to certain topics and resolutely dismiss rigid ideas of logical sequence and consistency.

There are certain permissible modifications, however, which may be made without violating the integrity of the system. To avoid the writing of long numbers a single letter may be used for the first three or four digits. Thus an Electrical Engineer would naturally have most of his material under 621.3 (Electrical Engineering) and for this number he could substitute the single letter E. Likewise a railroad man might use R for 625 (Railroad Engineering). Another modification consists in the use of an alphabetical arrangement for certain sub-sections combined with the decimal arrangement for main sections. This is sometimes useful in minute subdivisions. For example, under 621.728 (Material and Supplies for the Foundry) the various materials may be arranged in alphabetical order.

The use of form divisions is a modification that may often be employed to advantage. There are certain set forms that are used throughout the whole range of the Dewey classification. There are:

01 Philosophy or theory.
02 Compends, text-books, etc.
03 Cyclopedias, dictionaries, etc.
04 Essays, addresses, etc.
05 Periodicals.
06 Societies.
07 Education, teaching. Schools, colleges, universities.
08 Tables, calculations. Miscellanies.
09 History. Progress and development.

These forms may be further extended, thus:

064 Exhibits, etc. (under Societies).
072 Laboratories (under Universities).

Other form divisions that apply particularly to Engineering are the following:

001 Statistics.
002 Quantities and costs.
003 Contracts and specifications.
004 Designs and drawings.
005 Executive.
006 Working and maintenance.

007 Laws.
008 Patents.
009 Reports.

These form divisions may be enclosed in parentheses and annexed directly to the usual class number. Thus, 62(07) indicates Engineering Education; 621.32(09), Progress in Electric Lighting; 621.57(008), Patents on Ice-making Machinery, etc.

The object of this parenthesis separation of the form division is convenience in cross-references. For example, if one is interested in Patents he may write his class numbers as follows:

(008)62 Patents—Engineering.
(008)66 Patents—Chemical Technology.
(008)69 Patents—Building.

In this way all cards on Patents are grouped together.

Other modifications will suggest themselves to the user as he becomes more familiar with the system.

The Extension of the Dewey Decimal System of Classification to the Engineering Industries and to Architecture and Building

The Dewey Decimal System explained in the above paragraphs, has been extended by the Engineering Experiment Station of the University of Illinois to cover, in greater detail, the fields of engineering and architecture. The former is elaborated in Bulletin No. 9 by Messrs. L. P. Breckenridge and G. A. Goodenough, and the latter in Bulletin No. 13 by Mr. N. Clifford Ricker. These extensions have been very extensively adopted.

A feature of the classification is the "Relative" or Alphabetical Index therein given in addition to the elaborated "Topical" index. The "Relative" index enables a user to find the proper class number for any subject by the alphabetical method, without having to "step down" through the system to the logical location. This is a time-saver to most users; and to those not trained in systematic methods is the only means by which this valuable device is made available.

Bound Books for Indexing, Filing and Recording

Bound books are best suited to records that follow an unbroken consecutive order, and which are of a definite length never extended.

Examples.—(1) A Register of consecutive tracings made in an engineering office, giving number of drawing, title, date, job No., etc., as shown on p. 462. (Indexing.)

(2) A record of estimates made in the office of a bridge company, giving name of client, date, amount bid, etc. (Indexing.)

(3) Copies of telegrams, letters, etc., may be pasted in bound books in chronological order. (Filing.)

(4) A Diary of engineering procedure may usually be well kept in a bound book. (Recording.)

None of these examples call for future additional data, and are best kept in a bound book.

Card Index Methods for Indexing and Recording

Methods.—Card index methods, **as distinguished from bound book,** are better adapted to the indexing and recording of all material that may have to be added to, decreased, or rearranged at any future time.

Examples.—(1) Tracings that are filed in drawers in numerical order may have their subject matter indexed on cards which may be filed alphabetically. The cards may be added to, withdrawn, or entirely rearranged at any time; such flexibility in indexing being practically impossible if the records are kept in a bound book.

(2) Cards of the larger sizes are often used to record the principal data of estimates, contracts, inspections, etc. The possibility of filing such data by some system that will bring information of one kind all together, and which may be added to indefinitely as the work progresses, renders it superior to the limitations imposed by bound book methods.

Card indexes, **as distinguished from loose-leaf appliances,** are thought by many to be superior to the latter when rapid and **selective searching of an index** is required. An example occurs in the indexes almost universally used in libraries; the turning from card to card is done with no diversion of the eye, the mind, being thus undistracted, can retain without effort the impression that prompts the search, and the field of view is large and expandable. With loose-leaf books these advantages are, to some extent, lost; the turning of the pages introduces a certain amount of distraction which in many cases is sufficient to hinder the search. The same condition occurs in indexes for drawings, catalogues, etc.

Furthermore, in the examples mentioned, the very bulkiness of the drawers is a **protection against theft,** while at the same time the size of drawers is not so great but that any one may be taken from the case and placed on a table for better reference. Also the cards are certainly better able to withstand the constant usage of such files than are loose leaves.

It would seem, therefore, that for **indexing only,** cards are superior to any other appliance; for recording purposes their use is open to question.

For **recording data** the larger sizes of cards are usually used. If this data for each case will always be of limited and fixed amount and if it is of such a nature that the card will never have to leave the office, then the card system will answer the purpose. Under the opposite conditions, more especially when a considerable amount of the data has to be taken

from the office temporarily (as in the case of local estimating), the lack of portability is an absolute deterrent to the use of cards. Also the inability of obtaining more than one copy at a time from the typewriter or the pencil is a disadvantage; with loose leaves as many as six or eight carbon copies may be obtained from a typewriter. This disadvantage may be overcome to a certain extent, however, by using copying ink and obtaining manifolds from a copying press. Moreover, it is difficult to add to the record on cards, they have to be entirely removed from the case with the consequent danger of loss or misfiling upon return.

For **recording** various engineering operations in field or office the predominating value of the card index will depend on whether the function is related more closely to the indexing or recording operations described above. For limited, stationary records the card index is indicated; for voluminous, manifolded and distributable records the loose-leaf system is superior.

Since the above was written, however, the new **"Index Visible"** method of filing cards has been introduced, which not only greatly increases the rapidity with which a card may be located, but also renders easier the operation of inserting data on a card in the file; the feature of importability, however, is accentuated. For a description of this device, see p. 426.

In conclusion, **a word of warning** may be addressed to the young engineer who may be presented with, or who may be tempted to invest in a card-index outfit for keeping the various notes that all engineers should compile. For his purpose it is worse than the bound-book system, for it will surely be left behind at the first (or at most the second) change of residence; its lack of portability is a fatal defect. The loose-leaf system described in the following section is better suited in every way for keeping current engineering notes and data.

Appliances.—The appliances of card-index methods are in such universal use that any description of them is unnecessary here. The following notes, however, may be of suggestive value to those contemplating an installation.

Filing cabinets and drawers of all-steel construction may now be obtained; they have, of course, a certain value against fire damage.

The usual **size of card** for ordinary indexing is 3 in. × 5 in. The 4 in. × 6 in. size may be used where considerable data is to be recorded; while the 5 in. × 8 in. size is suitable for mercantile reports, ledgers, stock records, etc. Still larger cards, "letter" 9 1/2 in. × 11 3/4 in., "invoice" 7 1/2 in. × 9 7/8 in. and "cap" 9 1/2 in. × 15 in. may also be obtained.

Perforated cards, held in place by a rod through the drawer, should be used in all cases where cards will rarely be removed (as in most indexes), so that they will not be spilled in case the drawer is overturned. If

desired, the cards may be punched in various styles so as to prevent filing in wrong drawers. Ordinarily, however, the standard punching at the bottom and centre, with a locking rod, answers all requirements. Rods are extras, and should be specifically ordered.

In cases where cards must be frequently removed for the addition of records, the drawer should be fitted with a **stop** to prevent it from falling out with consequent spilling of cards.

Drawers may be fitted with Yale **locks.** Usually a line of drawers is locked by a bar controlled by one lock.

Cabinets may be obtained "finished" or arranged for attachment to other or **future sections.**

When an index is subdivided, **tab cards** of different colors should be used for the primary and secondary divisions. Tab cards are designated as "fifth cut (1/5 c)," third cut (1/3 c)," "half cut (1/2 c)," or wide center cut," depending on whether five, three, two, etc., in a set complete the line. Printed tab cards of the following styles are usually carried in stock; alphabets in 25, 50, 75, 100, etc., parts; numbers from 1 to 31, etc.; months; states; towns over 1,000 population; and blank tabs in any of the "cuts" described above. Movable tabs, for use in "follow-up" systems, etc., may also be obtained in various styles and colors.

For such operations as house renting, mortgage recording, insurance, etc., **special printed forms** are offered by the manufacturers, and these forms are very complete and suggestive; the engineer, however, will usually have to develop his own forms to suit particular needs.

Loose-leaf Methods for Indexing and Recording

Methods.—Loose-leaf methods, as **distinguished from bound book,** are subject to the same observations as made above concerning the card index, which need not be repeated here.

For **indexing** pure and simple the preponderating advantages of the card system have been stated; the same results can, however, be attained with loose leaves, but usually in not as satisfactory a manner. An **exception** occurs in cases where convenience and rapidity are not as important as the portability of the index; a good example of this condition being the index for engineering references described on p. 442. The book shown in the cut (Fig. 167) can be carried in an overcoat pocket, while a card index file containing the same amount of information could hardly be contained in a large suit case.

For general purposes of **recording** information, loose-leaf appliances are unsurpassed. The discovery and perfecting of this method of collecting, disposing and distributing the enormous amount of data entering and originating in engineering offices is one of importance not inferior to the discovery of the blue-printing process. Hardly any more valuable

gift could be presented to the young engineer than a loose-leaf outfit of suitable size, in which to record the particular notes, sketches, references, etc., pertaining to the line of work in which he is interested. As the data increases additional binders and blanks will be procured, separate books being used for different subjects: if the arrangement at first adopted has to be changed as the work or the point of view is altered, nothing has to be rewritten, a transference of leaves and perhaps an alteration in the index is all that is required: obsolete data may be retired making room for new: if a temporary assignment on particular work occurs, all data relating to that specialty may be withdrawn for the time, placed in a binder, and later returned to its proper place: furthermore the data is self-indexing, and a handy detail or formula does not have to be "done without" because the writer cannot remember in what book or where he copied it. The author has many times sincerely wished that, in addition to the usual graduation exorcisms to honesty, hard work, etc., he had at that time been introduced to the loose-leaf method of keeping engineering data and sketches.

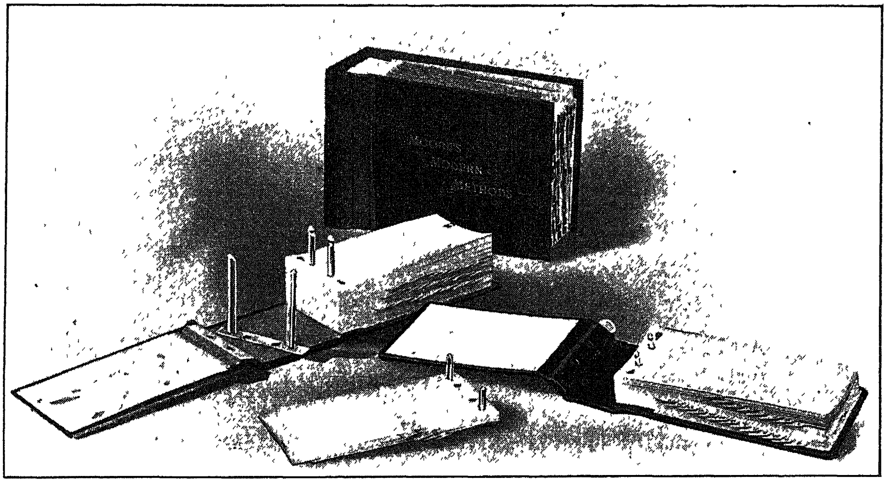


FIG. 167.—Loose-leaf binders.

Loose-leaf Appliances.—The catalogues of the manufacturers of loose-leaf appliances are extensively advertised and are easily obtainable; no attempt will be made in this book, therefore, to do more than illustrate those features of the appliances which are more particularly adapted to the requirements of the engineer.

There are two types of **binders** (covers) in general use, one using metal **rings** for holding the sheets, and the other containing metal **posts** on which the sheets may be slipped on and off. The former is the style largely used by students for keeping lecture notes; it has the advantage that its binding arrangement is not so bulky and stiff as with the "post" device, but it has the disadvantages that the opening and closing of the rings for

insertion or removal of new sheets is apt to tear the paper, and also that the sheets are not very securely held in place. For keeping temporary notes, however, whether for the pocket or the desk, these "ring" types of binders are quite satisfactory.

For any permanent data the "post" type of binder is indicated. The sheets can be readily inserted or removed without danger of tearing at the holes; they are quite securely held, and can, indeed, be locked in place (if the larger and more expensive binders are adopted) more securely than in bound books. The type of binder which is best adapted to the great majority of engineering requirements is the "four-post" binder, a typical example of which is shown in Fig. 167. The binders can be obtained in different thicknesses, to hold 200, 300, 700, etc., sheets, so that if a small binder is outgrown it is only necessary to transfer to a larger,

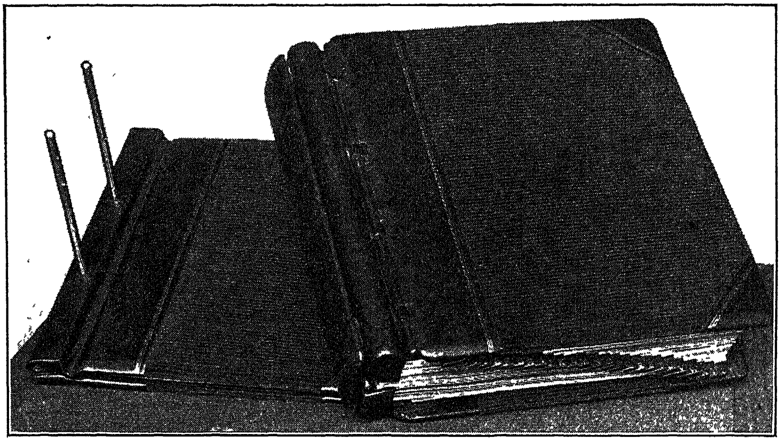


FIG. 168.—Loose-leaf current binder and transfer binder.

the operation requiring only a few seconds of time, and the old binder can be used for other records. Stiff covers are best for office use, while limp leather covers are preferable for traveling purposes.

Fig. 168 shows (on the right) a post binder in which sheets may be locked in position, and (on the left) a transfer binder for holding closed accounts or data not of current interest.

Cabinets for holding loose-leaf books may be obtained to hold from two volumes up, and additional cabinets may be added as desired without interfering with the continuity or appearance of the installation.

A six volume cabinet is shown in Fig. 169.

Standard **sizes of sheets** run about 3 in. × 6 1/4 in., 5 in. × 8 in., 8 in. × 10 in., 8 1/2 in. × 14 in., etc.

The **3 in. × 6 1/4 in. size** is convenient for carrying in the pocket, and may be used with advantage for discount sheets, or for holding such

data as may be useful to the sales engineer, or by the engineer who does much traveling in connection with his work.

The **5 in. × 8 in. size** will be found the most generally useful in engineering offices. It must be remembered that a smaller sheet may be used with the loose-leaf system than with bound books, because no space need be left on the sheet for future data or sketches, it is only necessary to use additional sheets as required. A surprisingly large amount of detail information can be placed on a 5 in. × 8 in. sheet, and the size of the binder is such that the volume can be easily handled and can be carried in a small grip or even in an overcoat pocket.

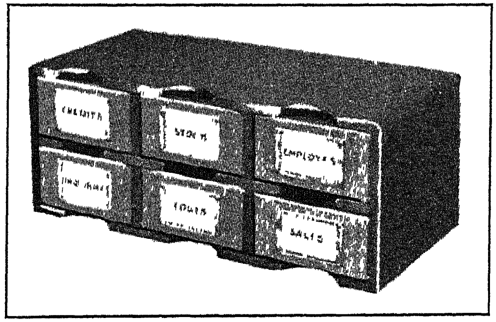


Fig. 169.—Six-volume loose-leaf book cabinet.

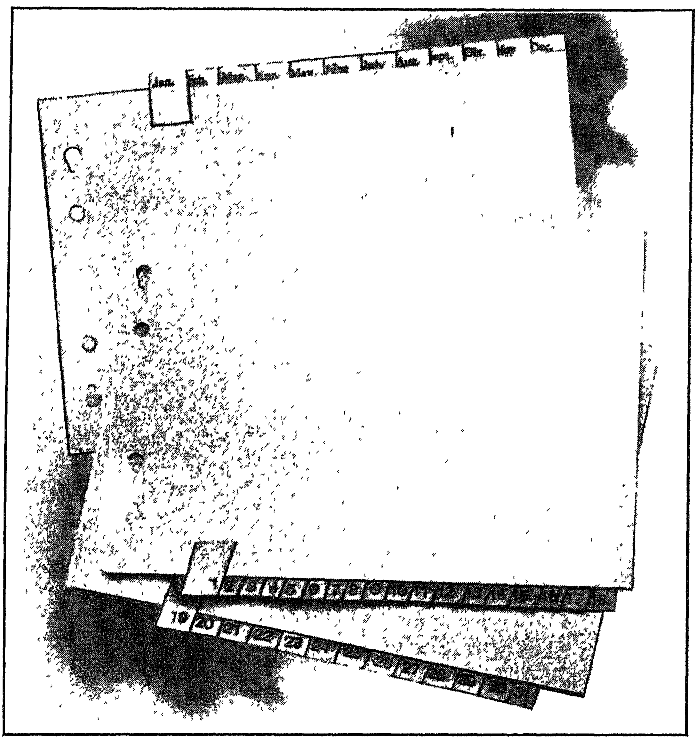


Fig. 170.—Loose-leaf tabbed index sheets.

The **8 in. × 10 in. size** is also well adapted to engineering office work; blue prints and photographs of good size may be pasted to the sheets, rendering it useful to sales engineers, offices compiling catalogues, and for many records of labor costs which often require extended tabulation.

For **indexing, tabbed index sheets** are used. These may be obtained in standard sets for alphabetical division in 26, 40, 80, 120, 540, etc., parts; for numerical division in 31 parts; for weekly or monthly divisions; geographical division (states); in blank; or in other special divisions to order. They may be obtained to show at the top, bottom or end, so that indexing to the third division in very convenient form may be obtained by the use of these tabs; while still further subdivision, by the use of tabs placed intermediately (as in the card index system) may be carried out indefinitely. Index sheets for monthly division on top, and for daily division below, are shown in Fig. 170.

THE "INDEX VISIBLE" METHOD OF INDEXING AND RECORDING[1]

This device, recently introduced, comprises important advantages over the old card index systems and is advertised as an improvement

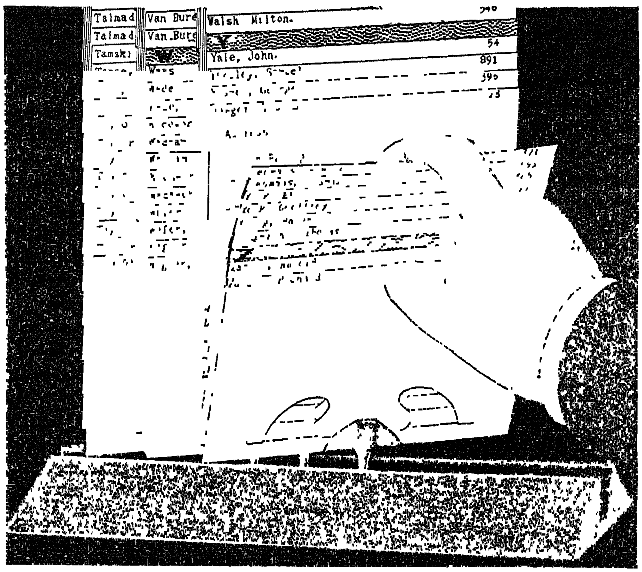


FIG. 171.—The "Index Visible" system.

on them. It may, however, be considered as an entirely different device, being almost as great an advance over the card index as that appliance is over the bound book for purposes of indexing and recording.

Figs. 171 and 172 illustrate the construction and operation of the index. Cards of standard size (3 in. × 5 in.) are shown, these cards being

[1] Index Visible, Inc., Times Building, New York City.

strung on a split strip of aluminum which is hung by a roller on an overhead rack. The cards are readily inserted and removed, and any card may be rendered entirely visible if desired by moving those above on the strip, their spacing not being destroyed by this movement.

The racks or cabinets are made in sizes to hold from 500 to 2,500, 3 in. × 5 in. cards, or equivalent.

The advantages of having the headings of all cards always visible is apparent: the saving in time in locating a card, the instant detection of a wrongly filed one, and the possibility of having a complete scheme visible at a glance, are points of great improvement over the ordinary card-index or loose-leaf methods.

For recording data the scheme possesses the advantage that no removal of a card is necessary; so that no misfiling when returning is possi-

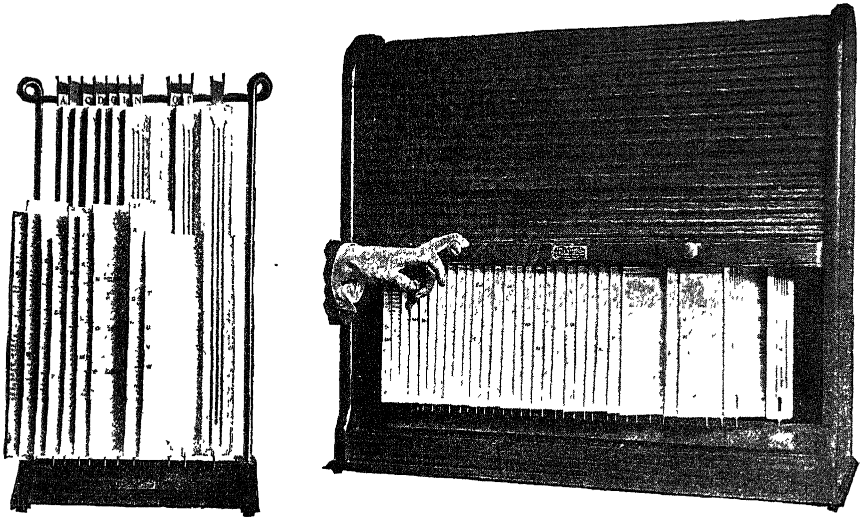


FIG. 172.—"Index Visible" stands (open rack and roll top cabinet).

ble; the strip is lifted from the rack, the card in question uncovered by slipping up the upper cards and the record can then be made with the file laid on the table.

The usual "follow-up" schemes can, of course, be applied as readily as to the card index, etc.

As with the standard card-index appliances, the importability of the device presents advantages and disadvantages.

For ordinary indexing it would seem that this device is superior to the card index; and for the recording of brief data, also, it possesses advantages over that system. For voluminous and manifolded records, however, the loose-leaf methods are requisite.

Correspondence Filing; Systems and Appliances

General Observations.—The term "filing system" sometimes refers to the appliances used for filing away letters, etc., and sometimes to the system under which they are filed, alphabetical, numerical, etc. Both of these topics are considered in the following paragraphs.

The "vertical" method of filing correspondence is alone considered, as it has almost entirely superseded other methods of filing.

The installation of a proper system of filing, with an appropriate index and other markers, is the predominant requirement; the choice of

Fig. 173.—Vertical letter file of "expandable" type; sanitary base (Shaw-Walker).

Fig. 174.—Vertical file with card index insert (Shaw-Walker).

appliances is secondary. A good system installed in a soap box is superior to one not suited to the requirements of the business, even though it be installed in the most expensive and up-to-date furniture.

The explanation of various systems of indexing and filing given below will apply, also, for drawings, estimates, orders, invoices, and all other data occurring in an engineer's office.

Appliances.—The principal details of the appliances are shown in the cuts accompanying this section. Fig. 173 illustrates a typical "build up"

filing cabinet of letter, cap or invoice size; and Fig. 174 shows a cabinet with a card-index insert, suitable for the Numerical, or similar systems of filing. Arrangements in great variety are presented by the various manufacturers.

Systems of Indexing.—The systems in most general use are:

(1) Direct Alphabetical.

(2) Combined Alphabetical aad Numerical.

(3) "Library Bureau" Automatic Index (Alphabetical combined with features of the Numerical.)

(4) Numerical.

(5) Direct Subject.

(6) Geographical (with various methods of subdivision).

(7) Subject Classification on a Decimal System.

(1) Direct Alphabetical System

This is the system in most general use, the **name** of the correspondent being the subject of the first or primary classification.

The **division of the alphabet** into a convenient number of parts is the first point to be considered. Such division must be based on the following requirements:

(a) The matter must be filed evenly, *i.e.*, some files must not become bulky and others contain few or no letters.

(b) The divisions must be such that the mental processes in filing and finding is reduced to a minimum.

(c) The divisions must be such that mistakes in operating will be reduced to a minimum.

The first requirement has been studied exhaustively by firms dealing in filing equipment, and for ordinary business requirements their assistance should be obtained in selecting an index. The difficulties of the subject will be apparent when one considers, for instance, the influence of locality on surnames; a business conducted principally with a town such as Milwaukee will have need for an alphabetical classification adapted to distribute properly a large proportion of German names; also, in New York City, the correspondents names will run largely on "Manhattan," "New York," etc. An engineering office is not usually confronted with the problem in just this shape, most of its correspondence being with a comparatively small group of names, wherein subdivision on another system is indicated.

In case it may be desired to make up such an index, however, it may be stated, as a guide for the operation, that each letter of the alphabet should be assigned a number of divisions proportional to the number of names it takes from the list on which the division is based. Thus, if 600 names (of machinery, supplies, etc.) are to be indexed by a 50-part alphabet, and the names beginning with "C" number 65; then each part will contain (approximately) $600 \div 50 = 12$ names, and "C" should be divided into $65 \div 12 = 5.4$, say, 6 parts. Also devices may

be used (such as "exception" folders), for relieving any folders which may become overcrowded.

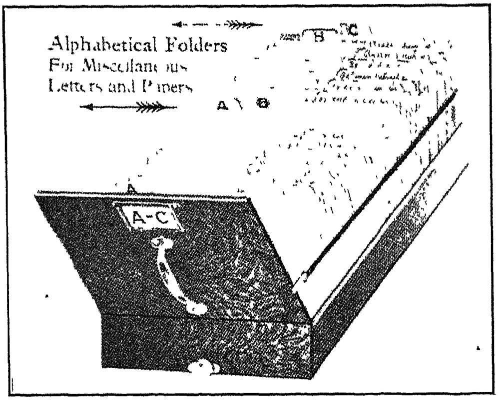


FIG. 175.—An index arranged on the alphabetical system (Globe-Wernicke).

The second and third requirements should be taken care of by using, in the index, limiting syllables having the greatest ratable value; by arranging these syllables one above the other instead of in a straight line and by other "short cut" devices of this character.

With regard to the **arrangement in the file of the guides and folders,** it is usually preferable to use, say, the first one or two divisions at the left-hand side for the alphabetical division guide; the next for the "Miscellaneous" folder for the division; and the

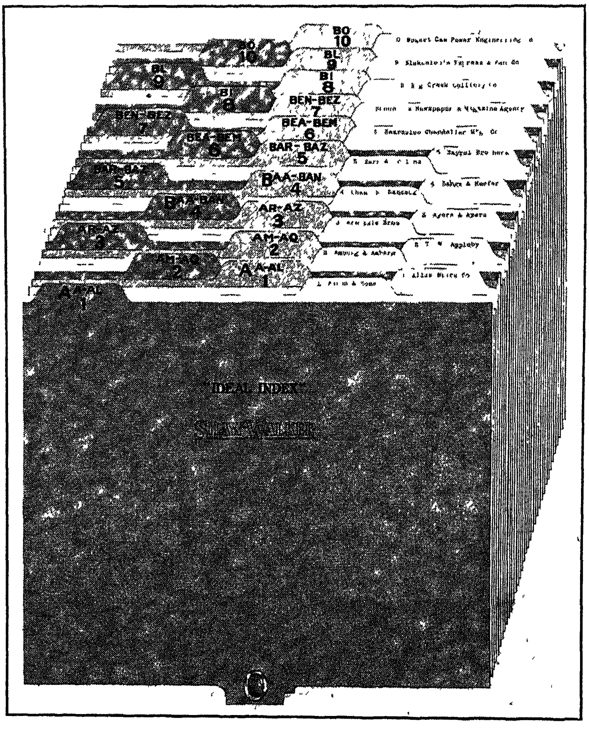


FIG. 176.—An index arranged on a combined alphabetical and numerical system. The illustration shows first ten divisions of a 100 sub-divided alphabet (Shaw-Walker).

right-hand side for the tabs or folders of individual correspondents. (See Figs. 175 and 176.)

When correspondence with any individual is very heavy, a convenient **subdivision** is **by months.**

Methods of **filing incoming and (copies of) outgoing correspondence** vary; separate folders or even separate files may be used; or the answer may be attached to the incoming inquiry; or both may be filed in one file strictly chronologically, irrespective of whether incoming or outgoing, this method being, perhaps, the best in the majority of cases.

(2) **Combined Alphabetical and Numerical System**

The only difference between this system and the alphabetical is that numbers are assigned to each alphabetical division, all the folders under any division bearing the same number. When taking out a folder, it is looked for under the alphabetical subdivision; but, as each folder bears a number corresponding to the guide behind which it is placed, all that is necessary, when returning it to the file is to place it behind the guide bearing the corresponding number. A check is thus obtained on the filing, and a misplaced folder asserts itself prominently.

An index arranged on this system is shown in Fig. 176.

(3) **"Library Bureau" Automatic Index**

This system is patented by the "Library Bureau,"[1] who are the sole makers of the indexes.

The first principle of the Library Bureau Automatic Index may be described as a **Primary** alphabetical division by **groups of surnames,** each subdivided into **Secondary** alphabetical groups by **given or firm name** guides. These secondary groups are identical under each Primary or surname division. It will be seen, at once, that the introduction of the given name, or of the second name of the firm, is a radical departure from the Straight Alphabetical system.

The second principle is the **numeric feature.** This may be described as a decimal system incorporated with the alphabetical, both to increase the speed in filing and to constitute a check on its accuracy.

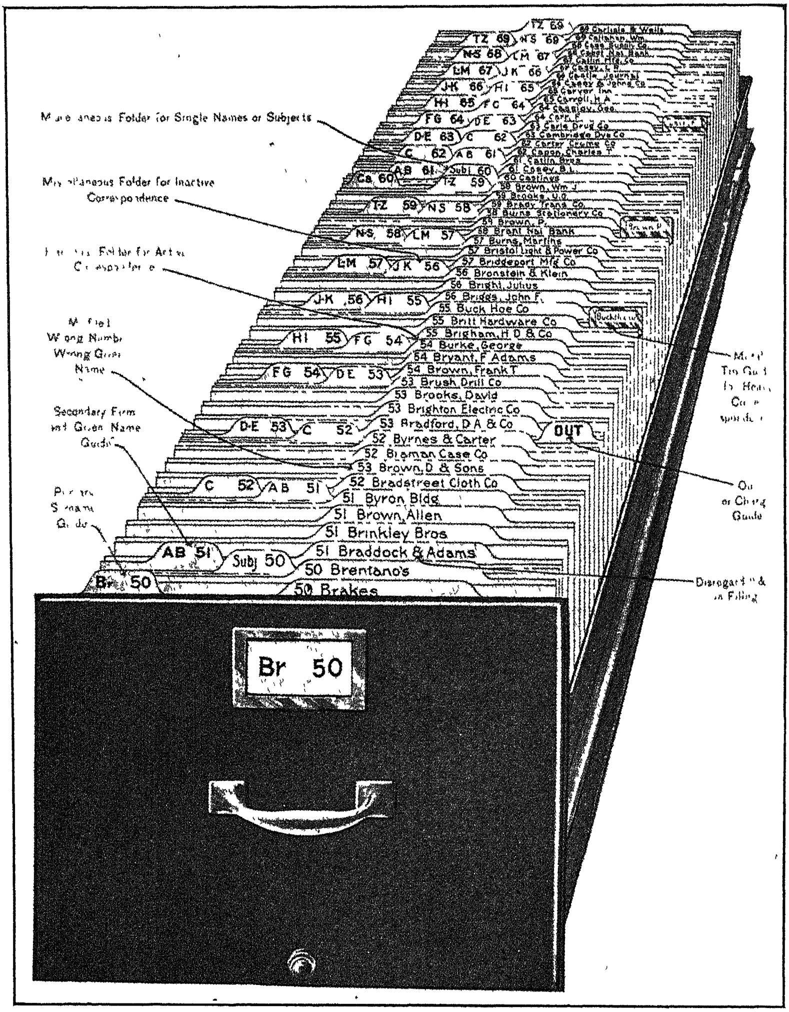
A typical file is shown in Fig. 177, and the key to the numeric system in Fig. 178, this key being printed on all guide cards and folders so as to be always available.

Considering the **guide cards** shown in Fig. 177, primary guides occupy the first row of projections at the left of the file, secondary guides comprise the second row, miscellaneous tab folders (for infrequent correspondence) constitute the third row, all three with the automatic file number printed at the **right** of the lettering.

Individual **folders** with wide tabs fill the fourth row, with the file numbers on the **left** of the name in juxtaposition to the guide card numbers; a device tending to the reduction of errors in filing.

[1] 316 Broadway, New York City; published by permission.

The use of the **numeric system** may best be described by an example. A letter from the Braman Case Co., is to be filed.



All folders are filed alphabetically back of their proper guides as in any filing system.

Allen Brown is filed back of the surname guide **Br. 50** (*Brown*) and is arranged in alphabetical order back of the given name guide **A-B 51** (*Allen*).

Buck Hoe Co. is filed back of the surname guide **Br 50** (*Buck*) and arranged in alphabetical order back of the second firm guide **H-I 55** (*Hoe*).

Brakes, a "subject" and *Brentano's*, a "single name", are filed alphabetically back of the surname guide **Br 50.**

The file number always corresponds to the numbers on the given name guides (see Fig. 178). The number therefore prevents filing back of the wrong alphabetic guide; simplifies the sorting and filing and saves labor.

FIG. 177.—Library bureau automatic index file.

On consulting the key (Fig. 178) the primary number is seen to be 5 (corresponding to "Br") and the secondary number is 2 (corresponding to

"C" in the smaller key); the file number, therefore, is 52; and the letter may be so marked, in the upper right-hand corner, for ease in filing. Similarly a letter from Martin Burns will be numbered 57, 5 corresponding to the surname Bu——— in the primary key, and 7 corresponding to the given name M——in the small (secondary key).

A	B	C	D	E	F	G	H	I-J	K-L	M	N-O	P-Q	R	S	T-U-V	WXYZ
Aa 1	Ba 3	Ca 6	Da 9	Ea 11	Fa 12	Ga 13	Ha 15	Ia 18	Ka 20	Ma 23	Na 26	Pa 28	Ra 30	Sa 32	Ta 36	Wa 38
Am 2	Be 4	Ch 7	Di 10			Go 14	He 16	Ja 19	La 21	Me 24	Oa 27	Qa 29	Ro 31	Se 33	U-V37	Wi 39
	Br 5	Co 8					Ho 17		Li 22	Mo 25				Sm 34		XYZ 40
														St 35		

GIVEN AND FIRM NAME KEY									
0	1	2	3	4	5	6	7	8	9
SINGLE NAMES OR SUBJECT	A-B	C	D-E	F-G	H-I	J-K	L-M	N-S	T-Z

FIG. 178.—Key to a 40 automatic division. In this key, printed on all guides and folders, the ciphers at right of primary guide numbers are omitted.

The **advantages of the system** may be summarized briefly as follows:

The numerical combination produces the most rapid method of getting matter into the file, and the most positive and accurate checks against errors in filing.

Letters or folders are filed by number, checked by name, or by name checked by number.

Reference to the file is directly by name, and the desired papers may be found instantly by any one. No index is necessary.

The Library Bureau Automatic Index requires but one-tenth of the number of alphabetic divisions required by other systems to accomplish equal results. The filing clerk has but to consider the 40 Primary division guides; the further subdivision by Secondary guides is identical in each group, and is quickly memorized.

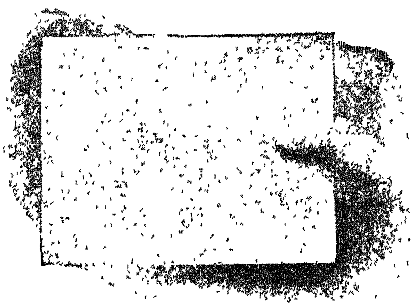


FIG. 179.—Folder containing all correspondence with one customer.

(4) **Numerical System**

The following description of this system is taken (by permission) from the catalogue of Koller & Smith, Inc.,[1] manufacturers of filing appliances.

"The principle of the numerical system in filing is the use of a number which stands for the name of the correspondent or subject. Strong manila folders are used, numbered in the upper right-hand corner. In these folders is filed the correspondence pertaining to the firm or subject which the numbers on the folders represent. Index to these folders is provided by means of cards ruled and numbered as shown by the illustration (Fig. 180.) On these cards

[1] 112 Worth St., New York City.

are written the name and address of the person, firm or subject to whom the number printed on the card has been assigned in the file. These cards are filed alphabetically in a card-index cabinet. All the letters received with copies of answers to the letters from a given firm are marked with the number of the correspondent's folder. To locate the folder, then, it is necessary to go to the card index to find the card bearing the name of the concern whose correspondence it is desired to look up, and the card will indicate the number of the folder in which the correspondence is filed. "*Cross Reference* by the numerical system is very simple, and in cases where there is likely to be a great deal of cross reference, the numerical system of filing is preferable. If there are two or more names concerned in the firm or company to which the file number has been assigned, a card is used for each of the additional names and the numbers written in the right-hand corner under the horizontal line (Fig. 181). This position is given to the number to indicate that this name is secondary in importance to the main one to which the number has been assigned. These cross-reference cards are, of course, filed in their proper alphabetical position and as many of them as necessary are used to make the locating of the folder quick and easy.

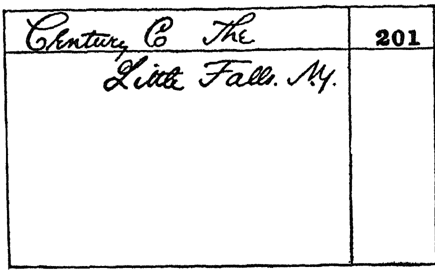


FIG. 180.—Card showing number assigned to correspondent. It is filed alphabetically and is an index to folder bearing same number.

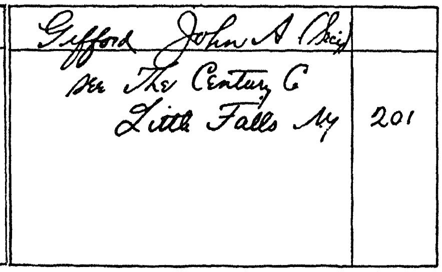


FIG. 181.—Cross-reference card insures papers being filed in proper folder which might otherwise be filed under new name or subject.

Subject Indexing.—The numerical system is peculiarly adapted to the cross-indexing of correspondence for subject-matter. A separate card index must, of course be installed, indexed by the alphabetical, topical or other suitable system. The following description of the system is taken (by permission) from the catalogue of the Amberg File & Index Co.[1]

"Subject Indexing is resorted to when it is desired to have a reference to the subject matter, in addition to the usual name indexing required to locate a folder by number. To permit of locating correspondence from one party on a certain subject, or from several parties on the same subject, requires cross-reference indexing by name and by subject. It will readily be seen that to index by subject successfully one must become acquainted with the contents of every letter and be able to classify related subjects under one common head, in order to avoid making cards under separate heads on subjects that are nearly indentical. It is distinctly individual work, *i.e.*, no two persons would index the same correspondence in

[1] Chicago, New York and London.

exactly the same way, and again no two correspondences are exactly alike. Each installation of "subject" indexing is really a study by itself and must finally be left for solution to the clerk who is to do the actual work of operating the system. Our illustrations indicate in a general way how to proceed. In the illustration "Individual Filing" the correspondence is filed in the regular way into numbered folders, as indicated by the first three cards; the fourth or subject card "Anodes, Nickel" indicates where correspondence on this topic may be found. Note that the correspondence from each party is kept together, the subject reference being brought about by making the additional record card."

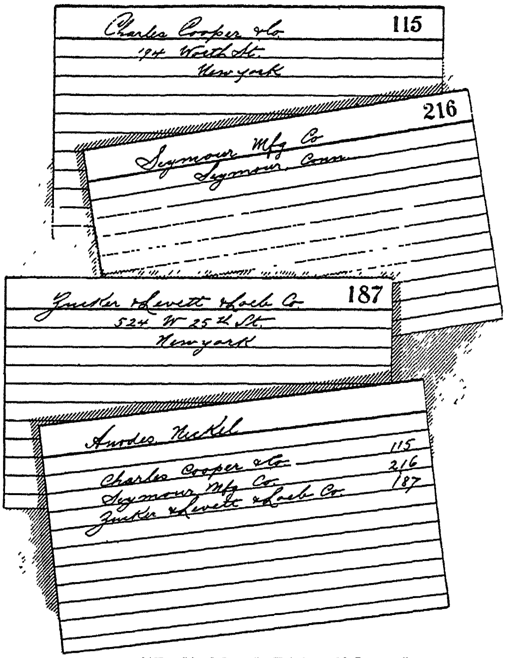


FIG. 182.—"Individual Filing" by the numerical system.

In the second illustration, "Subject Filing," the correspondence from each party is scattered, in this case being actually filed by subject. The first card (Vigers Bros.) indicates the filing to be: (1) general correspondence from Vigers Bros. in folder 52; (2) on the subject of Waldorf Hotel in folder 96a; (3) on the subject of Stockport Town Hall in folder 191c. The same explanation applies to the cards for Bath Stone Firms, Ltd., and Dorman, Long & Co., Ltd. The fourth card (Waldorf Hotel) is in this case the subject card. To complete the series of cards needed for this illustration you will observe that there should also be "subject" cards for Stockport Town Hall, New Sessions House, and Victoria Railway Station.

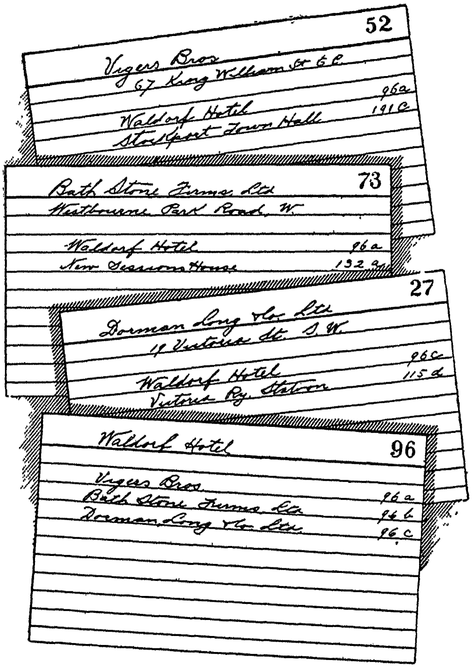


FIG. 183.—"Subject Filing" by the numerical system.

(5) Direct Subject System

This is a system which is peculiarly adaptable to the require-

ments of the engineer to whom the "Job Number" is the unit, or to those purchasing agents to whom the subject is of greater importance than the name of the writer, etc.

There are many varieties of the system, but the principal ones may be outlined as follows:

(a) An alphabetical system in which a tabbed folder is used with the subject written on the tab at the top (Bolts-Split, etc.), this folder being filed in its proper alphabetical position in the file and containing letters from all and sundry on this subject.

(b) A numerical system in which a file number is assigned to the subject instead of the name as explained in the numerical system above, a card index pointing to the folder number. Papers on the given subject are filed in the folder bearing this number without reference to the name of the correspondent. The names of the writers, however, may be cross indexed with reference to this number by the use of cards which are filed alphabetically.

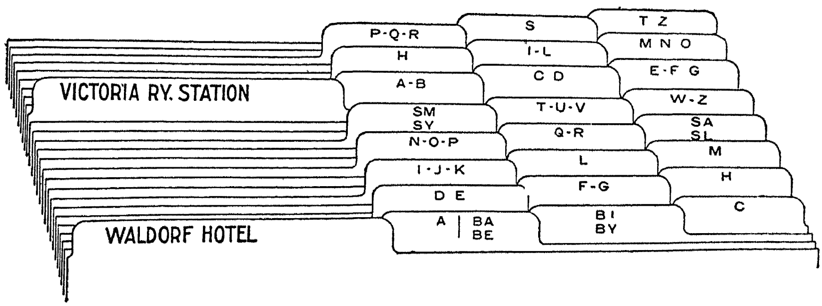


FIG. 184.—Arrangement of guides in vertical drawer for contract filing.

(c) A system having for its primary divisions the name or number of the job, with secondary divisions on the alphabetical system referring to the name of the correspondent. This system does away with the use of a card index or of a numerical system. The arrangement shown in Fig. 184 (from the Amberg cat.) was composed for the use of a Building Contractor, but the idea is adaptable to the needs of Architects, Contractors in Paving, Heating Plants, Bridges, Concrete, etc., in short, any business where it is desired to keep the papers filed by the Job or Contract they refer to. Or, instead of using the *name* of the job (filed alphabetically) as the primary division, the *number* may be used, filed numerically; an index being referred to if necessary, to give the job number.

For any of the above systems provision will have to be made for **Miscellaneous correspondence** which does not refer to any Job in particular. A separate drawer should be used for this matter, the index being arranged alphabetically.

(6) Geographical System

This system is not one which will ordinarily be used in an engineering office, but in some lines of business it is of great utility and is largely adopted, it being often more convenient, for example, to have all letters from one town together, than to have them scattered under correspondents' names. Varieties of indexing are as follows:

(a) Primary Divisions by States, Secondary Divisions Alphabetical.
(b) Primary Divisions by States, Secondary by Towns (arranged Alphabetically). The list of towns may include only those over 5,000, 1,000, 500, etc., with a "miscellaneous" folder for others.
(c) Straight Town Filing, arranged alphabetically; no labeling by States.
(d) Primary Division Alphabetical; correspondence filed according to *town* and not by correspondent's *name*.

(7) Subject Classification on a Decimal System

The following description of this system is extracted (by permission) from the catalogue of the "Library Bureau"[1] who have made a special study of this method of filling. For a description of the Dewey Decimal System, see p. 416 *et seq.*

Subject Classification Filing

"The advantages gained by filing correspondence by subject assumes such importance in some lines of business as to demand careful study of the problem.

"There are many difficulties to be encountered, chief of which is the confusion of subject headings, if the decision is left to the discretion of the file clerk. Again, synonymic terms often lead to separate filing places for the same topic, causing hopeless confusion.

"The Subject, in inter-office correspondence, in the public service corporation, the railroad, the large commercial house, is of primary importance, not the name of the writer. In the ordinary transactions, letters from several departments are passed back and forth for opinions or decisions and reference is invariably by the subject written upon. This is particularly true in railroad office correspondence."

A Numeric Subject Classification

"A Numeric Subject Classification assigns to each subject a number by which related subjects are filed in the same location.

"To establish a practical system, time and study must be devoted to the selection and arrangement of the main classes, divisions and subdivisions.

"First, all possible subjects relating to the business must be grouped under not more than ten classes. To each class is assigned a number, 0–9, which constitutes the first figure (from the left) of the file number. Next, each class is analyzed and divided into not more than ten divisions, each with its unit number. These form the second figure of the file number. Each of these divisions is again subdivided into not more than ten subclasses, forming the third figure of the file number.

[1] See ref. p. 431.

"The result is 1,000 possible subjects logically grouped. As still finer subdivisions are required, decimals are used expanding any division as far as desired. See illustration below.

"Occasionally the name of the writer is vital to trace a certain letter. When this condition assumes sufficient importance, a card index cross reference by writer's name is provided.

"The basis of this system is that employed in the Dewey Decimal Classification so widely used in library cataloging."

Results

"Subject Classification filing accomplishes two results: First, it brings all papers on one subject in one place, while those most closely allied precede or follow; second, it forces the file clerk, in fact every one in the office, to use but one term in describing one subject. The system is easily expanded; the numbering is uniform in any branch or department; the filing has the rapidity and safety of Numeric filing. Transferring of bulky and unimportant subjects may be effected as often as occasion requires without necessitating the complete overhauling of the file.

"Complete Subject Classifications have already been standardized for Railroad and Telephone company filing, and published in book form. Particulars regarding these treatises on request."

Illustration of Decimal Subject Classification Filing for Telephone Correspondence

The Main Classes

All possible subjects of the business are here grouped in six classes.

Classes **7, 8,** and **9,** are still left for future growth.

000 GENERAL
100. EXECUTIVE ADMINISTRATION
200. FINANCE AND ACCOUNTS
300. CONSTRUCTION
400. EQUIPMENT
500. OPERATION
600. RATES, ETC.

A Division under one of the Main Classes

Showing the amplification of the Main Class **200 Finance and Accounts,** into its ten divisions. Two series still left for future possibilities.

200. FINANCE AND ACCOUNTS
210.
220 Bonds and Capital Stock
230. Banks and Banking
240 Expenses
250 Accounts
260
270 Employees Accounts, Wages, Etc.
280 Pay Rolls
290. Bills and Vouchers

The Subdivisions

Here is shown a portion of Subdivision **255,** under class **200, Finance and Accounts:** division **250, Accounts;** subdivision **255, Exchange Accounts,** a portion of which only is shown.

Note the further classification to three decimals

255. EXCHANGE ACCOUNTS
 255.01 Method of keeping accounts
 255 03 Reports of traveling auditors
 255.04 Balances
  225 041 Calls for balances
255.1 Subscriber's Accounts
  255.101 Classification of Credits
 255.11 Accounts in suspense
 255 12 Charges for second party's use
 255.13 Authorities for transfer of charges

The Relative Index

Portion of the "M" section of the Index, arranged strictly alphabetically for daily use of the file clerks

255 01	Methods of keeping accounts (General)
295.41	Methods of preparing and handling vouchers
050.2	Methods for procuring rights of way
320 501	Methods of transposition, pole lines
502 9	Method, Two number
042 1	Micas
042 1	Microphon
360 031	Mileage of cables (statistics)
340.041	Mileage of conduits

The Subdivisions—(*Continued*)

255.14	Disputed accounts
255 15	Transfer of credits and credit balances
255.2	Subscriber's unpaid accounts
255.21	Adjustment of accounts
255 22	Extension of credit
255 23	Compromise settlements
255 24	Accounts sent to attorneys for collection
255 25	Bankrupt subscribers
255.251	Notices in bankruptcy
255 252	Proofs in bankruptcy
255 253	Assignments for creditors

The Relative Index—(*Continued*)

275 1	Mileage in employees' traveling expenses
320.031	Mileage of pole lines
601 86	Mileage rates
601 862	One party
601 863	Two party
601 864	Three or more parties
601 861	Mileage rates, basis for reckoning
321 001 1	Mileage of toll lines
323 011	Mileage, trunk lines
356.021	Mileage, wires
475.2	Mimeographs

Cross Indexing

This subject has been already referred to in the descriptions of the various indexing systems. The principal uses are:

(a) In the card index of correspondents' names used with the numerical system, a cross index to refer the *names of officials* to the name of the company under which their letters are filed; see Fig. 181.

(b) In a system where letters are filed by the name of the correspondent, an index of *subjects* referring to correspondent's name or number. This method involves a great amount of clerical labor which must be done *well* to be of any use; it should be installed only after a thorough study of the subject.

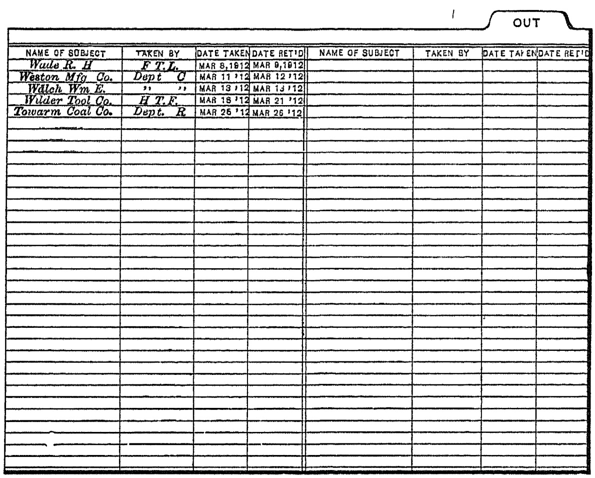


FIG. 185.—The "Out" or "Charge" guide for correspondence file.

If there is infrequent occasion for cross referencing, a card of folder size, suitably tabulated and placed in the front of each file drawer may be used instead of a card index.

"Out" Cards

These cards, of a distinctive color, indicate and locate a withdrawn file; see Figs. 185 and 177. The correspondent's name, name of the department or person by whom taken, and date are entered on the "Out" guide. The return of papers is noted by stamping the date against the last entry.

Transferring

This is the process of removing old matter from the current files to "transfer" cases. These transfer cases or files are usually of cheaper construction than the original. Several schemes are in common use:

(a) Complete transfer at stated periods, usually yearly.

(b) The use of double capacity current files, each holding a year's correspondence. At the end of the second year, the correspondence in the first year's file (one year old) is transferred, and the space thus vacated used for the ensuing or third year's papers, etc.

(c) The continuous transfer system, wherein all matter more than, say, a year old is removed from time to time to a second file, from which, in turn, older material is sent to the final transfer file at intervals. The transference may be done gradually, in spare times.

The first system is easy and cheap, but is open to the objection that, temporarily, reference to the transferred matter is as frequent as to the current file. The second system is well adapted to businesses where matter more than a year or two old is infrequently consulted. The third system is best for important correspondence, or where reference is frequent for several years.

A **record of transference** may be kept on a table printed on the current-file folders, or on a specially printed "transfer-record" card inserted in the file at each primary or secondary division.

The **folders** in the transfer files should be tabbed in the same manner as those in the active files, or else guide cards should be used, cheaper equipment for this purpose being allowable.

Whatever system may be used, it is never advisable to remove or transfer such folders as have become too full, leaving the others, but partly filled, in the file. Such a method, or rather lack of method, can only result in serious confusion; everything which bears a date prior to the date fixed for transfer should be transferred. (L.B.)

Follow-up Systems

It is often necessary in engineering work to install a "follow-up" system. Examples occur in the case of estimates to be handed in by a certain date, orders to be placed, shippers to be notified of required delivery, inquiries to be followed up, etc.

A device often used for this purpose consists in the affixing of a conspicuous tab to the card, page, etc., containing the record, in such a location that attention will be indicated on a certain date. Movable markers, especially made for this purpose, may be obtained from various stationers, but to complete the device a line of dates must be pasted on the back fly leaf or cover of the book, or on the end card of the card index, as a guide to the location of the marker. A common form of metal

marker, with accompanying date index, is shown in Fig. 186. Movable blank tabs may also be obtained for special uses.

Indexing and Filing Articles in Technical Periodicals, and Other Technical Information (General)

In the various engineering periodicals are constantly appearing articles of particular interest to certain engineers or engineering firms. In many cases only one small detail of a long article will appeal to the reader and he will note it with interest. Several months or years afterward he will be confronted with a problem upon which that detail would

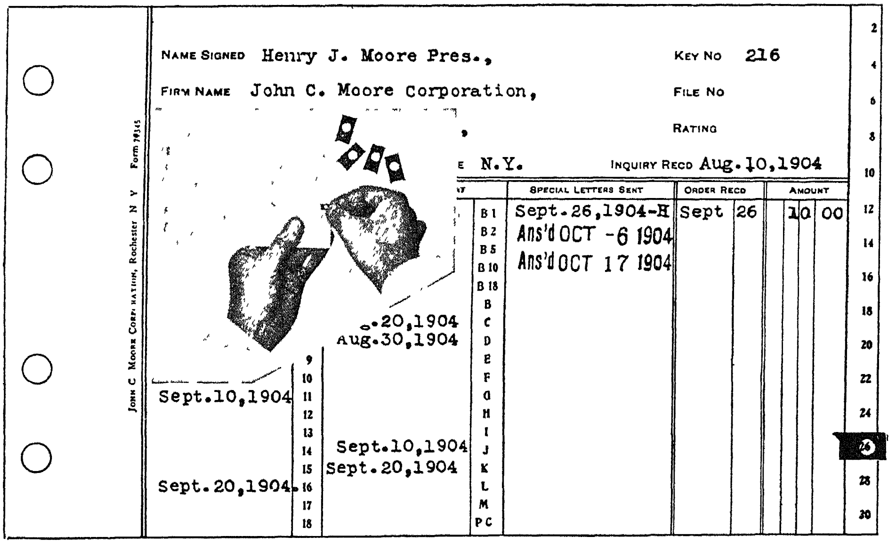

NAME SIGNED Henry J. Moore Pres.,
KEY NO 216
FIRM NAME John C. Moore Corporation,
FILE NO
RATING
N.Y.
INQUIRY RECD Aug.10,1904
SPECIAL LETTERS SENT
ORDER RECD
AMOUNT
Sept.26,1904-H
Ans'd OCT -6 1904
Ans'd OCT 17 1904
Sept 26
10 00
.20,1904
Aug.30,1904
Sept.10,1904
Sept.10,1904
Sept.20,1904
Sept.20,1904
John C Moore Corporation, Rochester N Y Form

FIG. 186.—Illustrating the "Marker" method of following-up. The movable metal marker shows that this record needs attention on the 26th.

shed a very clear light; he remembers having seen it, but in what periodical it was and in what number, he has entirely forgotten. He has not time to dig up his back numbers and go through them all (a wearisome task at best), and the regular engineering indexes may not be of much help because they deal with the article as a whole and not with the detail he remembers. Or, again, a problem is presented to an engineering office, the proper solution of which requires that all information relating to it, that it is possible to obtain, be first consulted. Such information may be obtained by consulting engineering indexes for several years back, referring to the articles, and extracting the data required; or the matter may be placed in the hands of such a research bureau as is maintained by the A.S.C.E. who will find and supply, in typewritten form, all the available information on the subject. Frequently, however, there is

no time for such a search, and it would be very much more convenient to have all such data filed together and immediately obtainable by the use of a suitable index. The larger engineering firms maintain libraries and technically trained librarians especially for this purpose, but for the individual and for the smaller engineering offices some less expensive system is required.

The following articles (pp. 442 to 445) describe two methods of solving this problem; they are intended to serve as suggestions for the building up of similar systems.

An Indexing System for Technical Articles

A system devised by the author provides for the indexing of articles of interest in a topical index based on the decimal system, and for the

C5. **Buildings**

.0 General
.1 Surveys
2 Foundations
.3 Mill Buildings
.4 Office, Loft, Hotel, etc., Buildings
5 Armories, Train Sheds, etc.
6 Theatres, etc.
.7 Residences
.8 Details of Construction
.9 N. O. L.

Subdivisions (For each)

0 General
1 Wood Frame
2 Steel Frame
3 Masonry and Plain Concrete
4 Reinforced Concrete
5 Combined Steel and R. C.
6 Combined R. C. and Masonry
7
8
9 N. O. L.

Fig. 187.—Typical index sheet for indexing engineering literature.

filing of the periodicals in the order of issue, or by the regular bound volumes.

The **index** itself is given in full on p. 449 *et seq.* It is arranged, and the references filed, in a loose-leaf book, using sheets 5 in. × 8 in. in size. A typical index sheet is shown in Fig. 187, and a typical reference sheet in Fig. 188. It will be seen that the latter is a specially printed form, devised so as to contain all the essential information concerning the article in as complete and condensed shape as possible. The "legal method" of referring to the number of the periodicals is used

(see p. 448); the length of the article is indicated; whether illustrated or not by "Y" or "N"; a subdivision of the index (either for the present or future) is allowed for; and finally a "form division" line indicates still further the character of the article. The "form-division" feature is adapted from that inaugurated by Mr. Melvill Dewey (see p. 418), and the divisions adopted are shown on p. 449; the figures being placed in brackets so as to distinguish them from the decimal division.

A system of **number tabs,** dividing the work according to the numbers of the index, is used, the numbers at the bottom of the sheet being for the first division, and those at the end for the second (see Fig. 167).

Under this system, no mutilation of the periodicals and pasting of the articles in books is necessary; the numbers may be sent to the printer and bound in the regular way, or the copies discarded and a

INDEX NO. *C 5.8* (   )

ALSO SEE

TITLE	VOL.	PERIODICAL	PAGE	GL'TH	ILL.	SUB INDEX	FORM DIV
Art Gallery Skylight & Ceiling, Spec. Constr., Det	*65*	*ER*	*404*	*1*	*Y*	*2*	*01*
Details of Sawtooth Roof	*65*	*ER*	*500*	*1/2*	*Y*	*1/2*	*01*
Floors for Mf'g Plants-Det's & Costs	*43*	*EM*	*567*	*10*	*Y*		*06 03 02 01*
Steel Framework Support for a Wide Cornice	*64*	*ER*	*664*	*1/3*	*Y*	*2*	*01*
Details of Sawtooth Roof	*63*	*EN*	*368*	*part*	*Y*		*01*

FIG. 188.—Typical reference sheet for indexing engineering literature. (Size, 5 in. × 8 in.)

regular library copy consulted when necessary. The author, however, has adopted the method of removing all the advertising matter from each number and then rebinding with a "Hotchkiss" or other type of permanent fastening clip. These separate weekly or monthly numbers are filed without binding; they can be readily found and removed from the file; and, if necessary, a number of them can be carried in a hand-bag, which is frequently a matter of great convenience.

It will be seen that the system is devised more particularly for the indexing of articles in technical periodicals, and this matter will supply the bulk of the data used by the engineer; but the indexing of other matter, such as books, bulletins, reports, etc., can readily be made on these special sheets. The filing of the material may be done under any system desired, as the index is not constructed so as to be "tied up" to any particular filing system.

A Simple Indexing and Filing System for Technical Data

The following system is well adapted to the needs of small offices working on a specialty; with proper care, however, it can be extended to the use of larger offices, or to those carrying on a wider range of work. In brief, it provides for the cutting out from periodicals, catalogues, etc., of any matter that may seem useful, and for the filing of the same in vertical files according to a topical index; the latter being either specially prepared for the needs of the office or being an extension of some such system as the Dewey (see p. 416).

Indexing

The success or failure of the system (as of all other such systems) depends largely on the preparation of the index. It should be compiled therefore, by one who has a thorough and broad experience in the line of work to be classified, and (of even greater importance) by one who is skilled in systematic methods. Two men with these talents separately developed may advantageously collaborate to produce a suitable index. After preparation it should be thoroughly tested by the "imaginary" filing of a wide variety of subjects chosen from the field of work. The following index, which was compiled more particularly to take care of data on cane-sugar factories, will serve to illustrate the style of classification required.

Topical Index

1. Financial and Economic Notes.
2. The Sugar Cane; its Varieties, Properties, etc.
3. Plantation Development and Equipment.
4. Field Operation.
5. Factory Installation.
    - 5.0 General.
    - 5.1 Building Material (Str. Steel and F. I. W. only).
    - 5 2 Factory Equipment.
    - 5.3 Other material; Lumber, Bricks, Cement, etc.
    - 5.4 Erection.
    - 5 5 Shipping Notes, Freight Rates, etc.
    - 5.6
    - 5.7
    - 5 8
    - 5 9
6. Factory Operation.
7. Marketing and Utilization of Sugar.
8.
9. Beet Sugar Notes.
10. Unclassified Notes.

The above outline shows only the main headings; actually these

are again divided, some on the decimal and some on the alphabetical system.

Filing

An ordinary "vertical" file, "invoice" size, is used to file the data. Paper folders hold all the sheets for each heading or subdivision, depending on the size of each; and "tabs," marked according to the predetermined system, index the file. Indefinite expansion is thus systematically provided for.

Articles in periodicals or catalogues may be cut out and filed at once without any further indexing; or, in case mutilation of the original is not desired, the article may be copied or photographed (see p. 492) and filed away. The elimination of the indexing of each article in a separate book is one of the advantages of the system. A useful appendix to the file, however, and one that supplies the advantages of a separate index, consists of a loose-leaf book outfit indexed to correspond to the file. In this book may be inserted references to books or articles which cannot be placed in the file, and also short notes or jottings that might become lost in the large file. It should be borne in mind, however, that this book is an appendix and not an index to the file.

SEC. III. MISCELLANEOUS METHODS AND SYSTEMS

Technical Letter Writing

(1) Do not write about several different jobs in one letter—let each job or theme be the subject of a separate communication; letters are quite usually filed according to the job to which they refer, and any admixture of subjects necessitates copying extracts in order that the files may be kept complete.

(2) Letters to business firms on matters in any way relating to the business should be addressed to the firm; if it is desired that the matter be taken up with some individual in particular, it may be sub-addressed, thus: "To the attention of Mr.———." If addressed to an individual it is liable to be regarded as personal, and in the event that the person addressed is out of town, is liable to be much delayed.

An exception to the above rule may be made where the matter, although relating to the business, is of a very confidential nature, in which case it should be written as a personal letter and marked "Personal."

(3) In writing on company business, the editorial "we" in distinction to the personal "I" should invariably be used. In case the writer desires to refer to himself particularly he may do so by the phrase "the writer."

(4) The subject should be handled in logical order and under distinctive "headings" and "sub-headings." "Unheaded" letters in a

DEVONIAN ENGINEERING CO.,
29 Broadway,
New York, N. Y.

Oct. 8, 1913.

The A. S. Campbell Steam Pump Works,
11 Broadway, City.
Gentlemen:
Referring to
Our Order No. 644—2–6 × 6 × 7 Pumps for the Cambrian Estates, Ltd.
In relation to
Drawings for the Erector and our Office Files.

Please forward us, for the above purpose, four copies of an outline drawing of the above pumps sufficiently complete so that arrangements can be made for piping to the same, incorporating in general-arrangement drawings and identifying at the Plantation.

Yours very truly,
Devonian Engineering Co.
JPD/H. Per

Fig. 189.—Example of "Headed" letter.

DEVONIAN ENGINEERING CO.,
29 Broadway,
New York, N. Y.

Sept. 15, 1913.

The Rutland Mfg. Co.,
Philadelphia, Pa.
Gentlemen: *Attention Mr. J. M. Richards*
Referring to
Your Order No. 5003. Cane Car Basculator for the Cambrian Estates, Ltd.
In relation to
General Arrangement Print of Hoisting Engine.

We beg to acknowledge receipt of your favors of the 12th and 13th inst. on the above subject and also print of engine from the Caradoc Mfg. Co.

We have looked over the same and are satisfied that the engine meets all requirements for power to be produced, etc. We wish to take this occasion, however, to call to your attention once more the matter of method of adjusting the lengths of the two ropes so as to obtain a substantially equal pull on both sides of the tilting table. We shall be glad to learn from you in due course the method you propose for accomplishing this adjustment.

In relation to
Delivery of Engine.

In accordance with telephonic conversation a few days ago with your Mr. Beddoes we hope to receive in the course of a day or two definite advice as to when you propose to ship this engine. As explained to Mr. Beddoes, the shipments to Macoris are few and far between, and we shall appreciate it if you will make a special effort to meet a shipment which will bring this hoisting engine at the Plantation in such time as not to delay the start of the taking off of the crop.

To this end we request that you take up the matter of probable shipment with the Cambrian Estates, Ltd., direct, as we have no control at all over this part of the business.

Yours very truly,
Devonian Engineering Co.
JPD/H. Per

Fig. 190.—Example of letter properly "Headed" and "Sub-headed."

letter file are very exasperating when quick reference is desired, almost as bad are "headed" letters that contain extraneous matter improperly inserted.

DEVONIAN ENGINEERING CO,
29 Broadway,
New York, N. Y.

Sept. 25, 1913.

The H. W. Carpenter & Sons Co.,
50 Church St., City.

Gentlemen:

Referring to

OUR ORDER NO. 642—SUGAR CONVEYORS AND ELEVATOR FOR THE CAMBRIAN ESTATES, LTD.

Please refer to your quotation dated New York City, Sept. 22, for the above material.

We beg to reply to the matters therein brought up as follows:

In relation to

SPROCKET WHEELS FOR SUGAR ELEVATOR.

The twenty-four tooth wheel proposed by you is acceptable.

In relation to

GALVANIZING ELEVATOR CHAIN.

This is not required.

In relation to

ELEVATOR BUCKETS.

The Salem 12 in. × 5 in. × No. 14 gauge galvanized buckets proposed are accepted. As stated on the drawing, this is a double strand elevator and the K-1 attachments proposed are approved.

In relation to

PERFORATED OUTLET FOR SUGAR REMELTER.

We note that you state it will be impossible to supply 1/4-in. holes in 1/4-in. metal, that the spacing of the holes is special, and that it might be admissible to use a plate of light, standard material at this location.

We presume that you refer to the use of punched holes at this point. If you will consult the drawing, however, you will find that this perforated area is quite small, and we believe that you will have no trouble in drilling these holes exactly as called for and at very slight expense. Please, therefore, make the construction at this point exactly as called for on our drawing.

In relation to

ADDITIONAL DRAWINGS FOR YOUR USE.

We enclose herewith one additional print each of our drawings No. 2659 and 2660 illustrating the material comprised under this order.

Yours very truly,
DEVONIAN ENGINEERING CO.
Per

JPD/H.

FIG. 191.—Example of letter properly "Headed" and "Sub-headed."

(5) The above are examples of letters "headed" and "subheaded" in such a manner that the eye can take in at a glance the main features of the argument, thus enabling concentration to be placed on each item in turn.

THE "LEGAL METHOD" OF REFERENCING TECHNICAL LITERATURE

This method[1] advocates the use of the system universally adopted by lawyers in their frequent references to precedent, etc. Thus, instead of indexing articles on "Steam Boilers":

Eng. Record, July 6, 1907
Cassier's Mag. May, 1907
Lond. Engr. Dec. 20, 1907

we may write:

50 Record 11; 32 Cassier's 47; 104 Lond. Engr. 620—the preceding number indicating the volume and the following the page—with very apparent advantages.

Text-books may be similarly tersely referred to; for example: "II. Thurston—Mat. of Eng. 68."

Catalogs also, if filed by serial numbers may have abbreviated reference as follows: "200 Cat. 40" a reference to sprocket wheels on p. 40 of catalog numbered 200.

The method is useful in making reference records (see p. 442), but the omission of the date (in a direct manner) would seem to be a drawback to its adoption for ordinary, current referencing.

A SYSTEM OF THE BRANCHES OF MODERN ENGINEERING, WITH A CLASSIFICATION OF THEIR OPERATIONS AND PRODUCTS

This outline is intended primarily as an aid to the formation of filing systems for engineering data, catalogues, etc.; but it is hoped that it will also be useful, especially to the younger members of the profession, in enabling them to get a broadening "birds-eye-view" of the whole system of modern engineering.

Notes:

(1) Engineering is an Art, not a Science.

(2) There are no hard and fast lines between the different divisions and subdivisions of engineering practice; furthermore, such boundaries as exist are constantly changing.

(3) A decade is sufficient to transform an almost unknown specialty into a branch of engineering involving the services of thousands of engineers and hundreds of thousands of dependent workers.

(4) The following scheme, therefore, should be recognized as being entirely individual, and as bearing no pretension as to correctness or completeness.

(5) The basis of the classification is the "product" or the "operation" (*i.e.*, the Subject Noun), and not any modification of the same, as "the cost of" or "the design of" (*i.e.*, the Adjunct Noun). The classification

[1] 61 Eng. Record, 142; A. L. Mengin.

of material according to the latter divisions may be coördinately effected by the "form-division" method. See p. 418.

MAIN BRANCHES	
Civil	C
Mechanical	M
Electrical	E
Mining and Metallurgical	Mi
DERIVED BRANCHES	
Industrial	In
Power Plant	PP
Railroad	R
Street and Electric Railway	SR
Municipal	Mu
Agricultural	Ag
ASSOCIATED BRANCHES	
Military	Mil
Naval	Na
CONSULTING BRANCHES	
Chemical	Ch
Sanitary	Sa

FORM DIVISIONS FOR ENGINEERING CLASSIFICATIONS

(00) General and Unclassified
(01) Design and Construction
(02) Erection,
(03) Costs and Quantities
(04) Philosophy or Theory
(05) History, Progress and Development
(06) Working, Maintenance and Repair
(07) Contracts and Specifications
(08) Measurements and Tests
(09)

Civil Engineering

C 1. Land Surveying
C 2. Railroads
- 2.0 General
- 2.1 Surveys
- 2 2 Earthwork
- 2.3 Tunnels
- 2.4 Bridges and Culverts
- 2.5 Track
- 2.6 Buildings
- 2.7
- 2.8
- 2 9 N. O. L. (Not otherwise listed)

C 3. Highways
- 3.0 General
- 3.1 Surveys
- 3.2 Earthwork
- 3.3 Bridges and Culverts
- 3.4 Surfaces

3 5 Structures (other than Bridges)
3 6
3 7
3.8
3.9 N. O. L.

C 4. Bridges
- 4.0 General
- 4.1 Substructures (Piers and Abutments)
  - 4.10 General
  - 4.11 Crib
  - 4.12 Pile
  - 4.13 Masonry or Concrete Piers
  - 4 14 Cylinder
  - 4 15 Reinforced Concrete
  - 4 16
  - 4 18
  - 4 19 N. O. L.
- 4.2 Railroad Superstructures (incl. combined R R. & H'way)
  - 4.20 General
  - 4.21 Wood
  - 4.22 Metal
  - 4.23 Combination
  - 4 24 Masonry
  - 4.25 Reinforced Concrete
  - 4.26
  - 4.29 N. O L.
    - Subdivisions (for each)
    - 0 General
    - 1 Girders and Trestles
    - 2 Trussed Bridges
    - 3 Cantilever and Continuous
    - 4 Suspension
    - 5 Arches
    - 6 Draw Spans
    - 7
    - 8 Details of Construction
    - 9 N. O L.
- 4.3 Highway Superstructures
  (Divide and subdivide same as 4.2)
- 4.4 Superstructures Not Otherwise Listed (N .O. L.)
  (Divide and subdivide same as 4.2)
- 4.5 Superstructures, General
  (Divide and subdivide same as 4.2)
- 4.6 Complete Crossings
  - 4.60 General
  - 4.61 Surveys
  - 4.62 Estimates
  - 4.63
  - 4.69 N. O. L.
- 4.7 Culverts
- 4.8
- 4.9 N.O.L.

C 5. Buildings
- 5 0 General
- 5 1 Surveys
- 5.2 Foundations
- 5 3 Mill Buildings
- 5 4 Office, Loft, Hotel, etc , Buildings
- 5.5 Armories, Train Sheds, etc.
- 5.6 Theatres, etc.
- 5.7 Residences
- 5.8 Details of Construction
- 5.9 N. O. L.

  Sub-divisions (for each)
  - 0 General
  - 1 Wood Frame
  - 2 Steel Frame
  - 3 Masonry and Plain Concrete
  - 4 Reinforced Concrete
  - 5 Combined Steel and R-C
  - 6 Combined R-C and Masonry
  - 7
  - 8
  - 9 N. O. L.

C 6. Waterways and Harbors
- 6 0 General
- 6.1 Surveys
- 6 2 Dredging and Dredging Machinery
- 6.3 Lighthouses, Buoys, etc.
- 6.4 Wharves and Piers
- 6.5 Drydocks
- 6.6 Canals, locks, etc.
- 6.7 Levees and River Dams
- 6.8 Harbors and Breakwaters
- 6.9 N. O. L.

C 7. Water Supply
- 7.0 General
- 7.1 Surveys
- 7.2 Dams, Reservoirs, Tanks, etc.
- 7.3 Pumping Plants
- 7.4
- 7.5 Distributing Systems
- 7.6 Purification Systems
- 7.9 N. O. L.

C 8. Tunneling

C 9.

C 13. Miscellaneous Structures
- 13 0 General
- .1 Retaining Walls
- .2 Smoke Stacks, Flues, etc.
- .3 Stand Pipes, Water Towers, Tanks, etc.
- .4 Signal Towers, Line Towers, etc.
- .5 Bins, Hoppers, etc.
- .6
- .7

.8 Details of Construction
.9 N. O. L.
Subdivisions (for each)
0 General
1 Wood
2 Metal
3 Combination
4 Masonry
5 Reinforced Concrete
6
9 N. O. L.

C 14. Miscellaneous Operations
14 0 General
.1 Soil Testing
.2 Boring
.3 Blasting
4 Waterproofing
.5
.6
.7
.8
.9 N. O. L.

C 15. Materials of Construction
15 0 General
.1 Wood
.2 Steel and Wrought Iron
.3 Cast Iron
.4 Other Metals
.5 Stone
.6 Brick, Tile, etc.
.7 Cement, Concrete and R-C.
.8 Paint
.9 N. O. L.

C 16. Appliances of Construction and Operation
16.0 General
.1 Derricks, Pile Drivers, etc.
.2 Concrete Mixers, and R-C. Tools
.3 Steam Shovels
.4 Prime-movers
.5
.6
.7
.8
.9 N. O. L.

C 17. Details of Construction
(Classify alphabetically)

C 18. Details of Operation
(Classify alphabetically)

C 19.

C 20.

C 21. Mechanics of Civil Engineering

C 22. Miscellany

Mechanical Engineering

M 1. Steam Engineering
- 1.0 General
- .1 Fuel
- .2 Steam Generators (Boilers and Furnaces)
- .3 Smoke Stacks
- .4 Engines
- .5 Condensing Machinery
- .6 Steam Pipe and Fittings
- .7
- 8
- .9 N. O. L.

M 2. Internal Combustion Motors
- 2.0 General
- .1 Engines
- .2 Accessories
- .3
- .4
- .8 Details of Construction
- 9 N. O. L.

M 3. Gas Production
- 3.0 General
- .1 "Lean" Gas Production
- 2 "Rich" Gas Production
- .3 Structures
- .4
- .9 N. O. L.

M 4. Hydraulic Machinery
- 4 0 General
- .1 Pumping Machinery
- .2 Hydraulic Motors
- 3 Hydraulic Pipe Lines
- .4 Hydraulic Presses
- .5 Hydraulic Accumulators
- .6 Hydraulic Rams
- .7 Hydraulic Machinery (Elevators, Hoists, Riveters, etc.; also see "Tools")
- .8
- 9 N. O. L.

M 5. Compressed Air Machinery and Blowers
- 5.0 General
- .1 Air Compressors
- .2 Compressed Air Motors
- .3 Compressed Air Tools
- .4 Compressed Air Accessories
- .5 Compressed Air N O L.
- .6
- .7 Blowers and Blowing Machines
- .8 Accessories for same
- .9 N. O. L.

M 6. Motors N. O. L.

M 7

M 8. Power Transmission (Mech. only)

M 9. Conveying and Elevating Machinery

9.0 General
.1 Conveyors; bucket, slat, scraper, etc.
.2 Elevators, bucket, slat, etc.
3 Elevators (Hoists); Rope, Plunger, etc.
4 Telpherage Systems (Overhead Cableways)
.5 Cable Railways (Surface and Sub-surface)
.6 Cranes; E. O. T., Hand, Loco., etc.
.7
.8
.9 N. O. L.
M 10. Machine Tools
10.0 General
.1 Wood Tools
.2 Metal Tools
.3 Stone Tools
.4
.9 N. O. L.
M 11. Special Machinery N. O. L.
M 12. Automobiles
M 13. Heating, Cooling and Ventilating
13 0 General
1 Heating and Ventilating Systems
5 Refrigerating Machinery
.9 N O. L.
M 14. Aerial Engineering
M 15.
M 18. Miscellaneous Structures
M 19. Miscellaneous Operations
M 20. Materials of Construction
20.0 General
.1 Wood
.2 Rolled Steel and Wrought Iron
.3 Cast Iron
.4 Cast Steel
.5 Brass, Bronze, etc.
.6
.9 N. O. L.
M 21. Appliances of Construction and Operation
M 22. Details of Construction
(Classify alphabetically)
M 23. Details of Operation
(Classify alphabetically)
M 24.
M 27. Mechanics of Mechanical Engineering
M 28. Miscellany

Electrical Engineering

E 1. Units
E 2. Electric and Magnetic Circuits
E 3. Measurements and Measuring Apparatus
E 4. Materials of Construction
E 5. Magnets
E 6. Transformers
E 7. Direct-current Electric Generators

E 8. Alternating-current Electric Generators
E 9. Direct-current Electric Motors
E 10. Alternating-current Electric Motors
E 11. Batteries
E 12. Central Stations
E 13. Transmission and Distribution
E 14. Illumination
E 15. Electric Traction.
E 16. Electro Physics
E 17. Electro Chemistry
E 18. Telephony
E 19. Telegraphy
E 20. Wiring
E 21. Miscellaneous Applications
E 22.
E 25. Mathematics and Mechanics (General)
E 26. Miscellany

Mining Engineering and Metallurgy
Mi 1. Exploration and Prospecting
Mi 2. Practical Mining
Mi 3. Working of Mines: Exploitation
Mi 4. Ventilation and Lighting of Mines
Mi 5. Drainage
Mi 6. Hoisting and Transportation
Mi 7. Mechanical Preparation: Ore Dressing
Mi 8. Dangers and Accidents
Mi 9.
Mi 10.
Mi 11. Metallurgy of Iron and Steel
Mi 12. Metallurgy of Gold and Silver
Mi 13. Metallurgy of Copper.
Mi 14. Metallurgy of Lead, Zinc and Tin
Mi 15. Metallurgy of Other Metals
Mi 16. Fuels and Furnaces
Mi 17. Assaying
Mi 18.
Mi 21. Cement
Mi 22. Sand and Gravel
Mi 23. Stone
Mi 24. Clay and Brick
Mi 25.
Mi 28. N. O. L.
Mi 29. General Articles

Industrial Engineering
In 1. Natural Resources
In 2. Construction and Equipment of Manufacturing Plants
2.0 General
.1 Choice of Location
.2 Construction
.3 Equipment
.4
.9 N. O. L.

In 3. Construction and Equipment of Storage Plants. (Subdivide same as In 2)
In 4.
In 5. Processes. (Classify alphabetically)
In 6. Products. (Classify alphabetically)
In 7.
In 8. Industrial Economy
8.0 General
.1 Education
.2 Management Engineering
.3 Engineering Forms, Reports, Systems, etc.
.4 Valuations
.5 Business Procedures
.6
.9 N. O. L., Miscellaneous Industrial Economics
In 11. N. O. L.
In 12. General Articles

Power Plant Engineering
PP 1. Surveys, etc.
PP 2. Structures
PP 3. Equipment
PP 4. Power Transmission
PP 5.
PP 8. N. O. L.
PP 9. General Articles

Railway Engineering (Operation and Maintenance)
R 1. Track
R 2. Structures
R 3. Motive Power
R 4. Rolling Stock
R 5. Traffic
R 6. Organization
R 7.
R 9. N. O. L.
R 10. General Articles

Street and Electric Railways
SR 1. Track
SR 2. Structures
SR 3. Rolling Stock
SR 4. Power Generation
SR 5. Power Distribution
SR 6. Traffic
SR 7. Organization
SR 8.
SR 9. N. O. L.
SR 10. General Articles

Municipal Engineering
Mu 1. Surveys
Mu 2. Streets and Sidewalks
Mu 3. Parks and Boulevards
Mu 4. Bridges
Mu 5. Water Supply

Mu 6. Sewers
Mu 7. Refuse Disposal
Mu 8. Sewage Treatment
Mu 9. Public Buildings
Mu 10. Building Laws
Mu 11.
Mu 15. N. O. L.
Mu 16. General Articles

Agricultural Engineering
Ag 1. Drainage
Ag 2. Structures
Ag 3. Equipment
Ag 4. Methods
Ag 5. Irrigation
Ag 6. Forestry
Ag 7.
Ag 9. N. O. L.
Ag 10. General

Military Engineering, Mil.
Naval Architecture, Na.
Chemical Engineering, Ch.
Sanitary Engineering, Sa.

CHAPTER XII

DRAWING-OFFICE SYSTEMS AND METHODS

SEC. I NUMBERING, INDEXING AND FILING DRAWINGS

General Observations

There are many different systems in use for numbering, indexing and filing original and "outsiders'" drawings; for the requirements of different engineering offices vary very largely. In certain lines of work, however, methods have become standardized; this being particularly true in the case of structural steel detailing; the various offices of the American Bridge Company having been put on a uniform system, and many independent bridge companies having copied their drawing office methods. The requirements in the offices of consulting, manufacturing, municipal and other engineers, however, usually demand special treatment to meet the conditions presented in the most efficient manner.

Some typical requirements are as follows:

Mr. "A" may demand, at a few moments' notice, all the drawings pertaining to a particular job; Mr. "B," who knows nothing of the customer's name or the job number, requires all drawings showing 7 ft. $\times$ 20 ft. multitubular boilers; Mr. "C" remembers, only, that about 5 years ago a certain drawing was made of a special gantry crane, and he wants it immediately so as to answer a telephonic inquiry; or, Mr. "A's" requirements may be more definite, he wants the drawing of the discharge gate of a vacuum pan built for Mr. "D" 3 years ago.

In installing any system, it should be examined in the light of requirements similar to those cited; and it should be able, within reason, to take care of the demands of all the above gentlemen, or of others who may come along in the near or distant future. The memory of the chief draftsman should in no wise be relied upon, although in all cases it will be found that a good knowledge of the system is requisite for quick finding of information; brains, and the use of them, being an indispensable adjunct to any filing system.

Various systems are described in the following pages, the intention being that they serve as suggestions toward the installation of one best adapted to particular requirements.

THE "CLASS AND SHEET-NUMBER" SYSTEM OF NUMBERING AND FILING ORIGINAL TRACINGS

In many drawing offices it is desirable that the original tracings be filed according to "class;" that is to say, that all drawings of mill-beds, or of crystallizers, or of 5-ton trolleys for hand cranes, etc., etc., be filed in separate drawers. Instances occur in the case of machine shops or manufacturing plants that specialize on a few lines of work; as, for example, a plant that makes a specialty of sugar machinery, mills, evaporators, vacuum-pans, etc.; or one confining itself to railroad-cars of all types.

For such offices, the advantages of having all similar tracings in one drawer (or in contiguous drawers) is obvious. The manager, or engineer, or draftsman, can see, almost at a glance, all that has previously been done on the part of that machine that is under discussion. The same drawings filed under another system could, of course, all be located and assembled by means of a card-index; but the necessity of immediate consultation of all old designs is, in a plant of this character, a matter of frequent occurrence, so that the "topical" filing of tracings is of paramount importance.

The system consists in giving to the drawings a number to designate the "class" of the object shown, as the figure before the decimal point, or as the numerator of a fraction; and a sheet number as the number after the decimal point, or as the denominator of a fraction. For example: "86.46" or "$\frac{86}{46}$" locate the tracing as belonging to class (or drawer) 86, and as sheet number 46 in that drawer, class 86 comprising, say, "Furnace Fronts."

It will be seen that the system requires that a comprehensive classification of all articles that are being (or are likely to be) manufactured be made in advance. Herein lies one difficulty in installing the system, for, if the classification and division of parts of machines be not made with judgment and foresight in the first place, troubles are likely to arise after a few years use owing to the too rapid filling-up of files that have a title of too general significance, and from other causes. It should be noted, however, that it is not strictly a "decimal system," so that the troubles due to improper classification in the latter (due to a limitation to ten divisions), are not met with in the "class and sheet-number" system.

In making up the classification the following limitations must be kept in mind: (1) Divide sufficiently so that no classes will be likely to have an excessively large number of sheets after a few years use. (Note.—A large number of sheets in a class, after, say, 5 years use will not necessarily be cumbersome; because the older sheets, which will be largely superseded, can be left in the older drawers which need seldom

be used). (2) Place details that may be used on a variety of machines in a class by themselves; do not classify under a particular machine. (3) Leave a few numbers vacant in the sequence at places where an extension of a particular line seems probable. (Note.—This is a procedure of doubtful utility and should be adopted with caution). (4) Take the first numbers, say from "1" to "10" or "20" for "Shop Tools," "Plant Buildings," etc., leaving several blank numbers for unforeseen plant needs. (5) Have cabinets and drawers constructed so as to be interchangeable, so that new drawers may be inserted at any place where the tracings of one class outgrow one drawer. (5) It is not necessary that there be, at the first, a separate drawer for each class; large envelopes or folders of stout paper may be used in which to file the tracings of one class, several of these folders being placed in one drawer.

A Record or Register of the tracings must be kept so that numbers may be kept consecutive, misplaced tracings identified, etc. For the reason that this record will grow unevenly, a bound-book will not do,

Class		Furnace Fronts, etc	Class No 86.
Sheet No.	Date	Title	Original job No.
740	June 2, 1906. ..	C. I Front for Dutch-oven Furnaces	1,153
741	July 7, 1906..	Furnace Mouth for Bagasse Furnace	1,176
742	July 7, 1906. .	Liners for Furnace Mouth.........	1,176
743	Sept. 20, 1906.	Sh. Iron Front for 66-in. M. T. Boiler..	1,213
744			

Fig. 192.—Sheet of register for class and sheet number system of filing tracings.

a loose-leaf book must be used (see p. 422). Numbered tabs should be used to mark the "class." A book having sheets 8 in. × 10 in. or even larger is best; and the sheets may be ruled as shown in Fig. 192. When a drawing is completed, the draughtsman ascertains the class number to which it belongs, and then takes from the record book the next number available and enters the date, etc., in this book. It should be noted that there is no sequence of numbers irrespective of class; *e.g.*, there may be drawings numbered 85.746, 86.746, 91.746, etc.; each class starts with sheet No. 1.

When the number of drawings reaches a certain point, considerable time will be lost looking through a drawer for any particular tracing, so that a card index will become necessary. This may be arranged on an alphabetical classification for the whole; or with a "class number" classification corresponding to the tracing-filing system for the first division, and either alphabetical, size, or other system of divisions for the second. Thus, if the latter scheme is adopted, a tab card "80—

Boilers, M. T., Extn. Front" would indicate the class, and if the cards were arranged in order of size of boiler, the drawing-number for a 66 in. × 18 ft. would quickly be found. Otherwise a hundred or more boiler tracings might have to be examined to find the one wanted. It should be noted, however, that the Record Book described above could conveniently be consulted, and a card index would only be an advantage when the number of the tracings became very large.

On each contract, a record of the drawings used should be kept, or a complete set of prints for the job may be made and filed.

The system is one that, for a small shop, requires a minimum of indexing and recording; the record book described is the only record that need be kept, and the drawings are self-filing. Furthermore, it is an easy system to which to change any existing unsatisfactory system; or to adopt in places where no system at all has obtained; for a large number of drawings on hand render the making of a classification an easier matter than when all work is *in nubibus*.

The "Consecutive Number" System of Numbering Tracings

In this system every tracing made by the firm bears a number of a consecutive order, irrespective of the job number or the date; so that every drawing issued has its own individual number, and no two drawings made by the firm ever bear the same number. What may be called the "job and sheet number" system starts numbering its drawings No. 1, 2, 3, etc., for every job. The "consecutive number" system is very generally used, and should be carefully considered by all engineers starting or revising a drawing office system. There are certain lines of work, however, to which it is not well adapted, as, for example, structural steel detailing; see p. 462.

Among the advantages of the system is the fact that there can never be any doubt as to the drawing referred to by a correspondent. A contractor or agent, who might have occasion to refer, by letter or cable, to a drawing of a certain number, would, under the older system have to be careful to give the job number also; if he had already received drawings on other jobs, the omission of the job number might lead to grave mistakes.

The system also lends itself well to the indexing of drawings under any desired headings, as reference to any drawing is not complicated by a job number.

The "Drawing Number Register Book" used in connection with the system may be ruled as follows: (See Fig. 193.)

The "drawing numbers" should be put in in advance with a consecutive numbering stamp; as, if left to the draftsman, "overlapping" of numbers is apt to occur. The register should be kept in a strongly bound book in preference to a loose-leaf book or to cards.

The draftsman fills out the record as each drawing is made, and the checker verifies the entry.

A convenient check-mark opposite the drawing number may be used to show that the drawing has been entered in the "movement record" (see p. 475), and another check mark will indicate that it has been properly entered in the "job" and "subject" card index. Periodical inspection of these marks will prevent the "forgetting" of drawings produced.

The filing and card indexing of tracings numbered according to this system is described under "Cross Indexing Special Drawings for Designs of Probable Future Usefulness" on p. 472.

The "Job and Sheet Number" System of Designating Drawings

On certain classes of work where an excessive number of small drawings have to be handled, as, for example, in structural steel detailing, the "consecutive number" system of designating drawings becomes unwieldy. The method usually adopted, therefore, is the "job and sheet

Drawing No	Date	Kind of drawing	Title	Job No
2728	Nov. 5, 1912	. . . . .	Location Diagram for Crystallizers .	176
2729	Nov. 6, 1912.			

Fig. 193.—Heading for drawing number register book.

number" system, where, for every job, the drawings bear numbers 1, 2, 3, etc. A disadvantage of this system, as has been explained above, is that unless the job number is also given in designating a drawing, there is liable to be some ambiguity as to which drawing is referred to when the correspondent has drawings for a number of different jobs.

In practice, however, the correspondent on this class of work is usually alive to the contingency and is careful to guard against it.

The system is more particularly adapted to work, which, in the course of a few months, can be definitely wound up, and the drawings filed away; structural steel detailing is work of just this character. For a consulting engineer's office, or for a manufacturing establishment, the system is not well adapted, because under it, it is not easy to provide for the use of standard drawings, and the record keeping and filing system becomes too complicated.

No separate "Register Book" such as is used with the "consecutive number" system is necessary. The registering of the drawing is made by the draftsman (before starting the drawing) in the drawing "Record Book," sample sheets of which are given on p. 478. The drawing may also be card indexed under any desired classification, although this is rarely done in structural work.

Some of the steel companies have adopted a system of sheet numbering that greatly facilitates the location of a desired print. Instead of simply assigning numerals, a prefixed letter is used, usually of mnemonic significance. Thus a sheet numbered "E5" is immediately recognized as a large sized erection drawing, "F56" as being a small-sized beam detail sheet, and so on.

A typical system is given below:

Kind of sheet	Contents	Remarks
E	Anchor-bolt and Erection Plans	Plain sheets
(no letter)	Riveted Work, and stairs, railings, etc	Plain sheets
F	Beams, channels and small riveted work (framing)	Plain and printed forms.
C	Castings, Anchor-bolts, seps., tie-rods, pins, rollers, rivets, bolts, crane rails.	Plain and printed forms.
S	Shop Bills for Riveted Work . .	Printed forms
B	Shop and Shipping Bills..	Printed forms
R	Shipping Bills .	Printed forms.
SC	Doors, windows, reinforcing metal, etc .	Plain sheets
EF	Corrugated steel lists, flashing, gutters and leaders, lumber fastenings, erector's list of field rivets and bolts.	Plain and printed forms.
K	Index	Printed forms.

FIG. 194.—Standard sheets for structural steel detailing.

The drawings are numbered E1, E2, C1, C2, etc., starting with No. 1 for each letter. The "E" sheets, and the large detail sheets which have no prefixed letter, are usually large sheets 24 in. × 36 in., 12 in. × 36 in., etc., the other sheets are usually 11 in. × 17 in. in size, although for very small or very large jobs this rule is not followed.

It should be clearly borne in mind that all references to structural steel methods made above, refer only to the detailing office; the designing office of a steel company is actually in the position of consulting engineer, and their filing, indexing and recording systems may profitably be modeled on the methods of the latter.

Numbering and Filing Tracings by Size

In the majority of drawing offices, standard sizes for tracings are adopted. The advantages gained by such restrictions in sizes are, (1) ease in filing and obviation of loss of small drawings among large ones, (2) convenience and improved appearance of bound folios of uniform-sized sheets, (3) economy in use of tracing cloth by using sizes to cut without waste, (4) possibility of obtaining sheets already cut and printed with border lines, title, etc., thus saving draftsman's time in doing this work, and (5) saving of time in folding prints for mailing, due to having envelopes of sizes to suit uniformly folded prints.

Possible objections are, (1) the additional requirement on the draftsman of choosing a scale and laying out his work so as to come within a given space, (2) the need of having several sizes of drawers to suit different sizes of tracings, and (3) the distribution of drawings belonging to one job in several cabinets or drawers (when tracings are filed according to job number).

For large offices the need of uniform sizes is imperative, but in smaller offices the objections given above may carry considerable weight. If there is any prospect, however, of the small office developing into a large one, and the system of filing is not according to the job number or similar, the multiplicity in drawer sizes is no great objection, as all tracings can be filed, for the time being, in the larger drawer.

Under a system of standard tracing sizes, the "drawing number" is usually modified to indicate the size of sheet. This may take the form of a letter, numeral, fraction, etc., placed as a prefix, suffix, numerator or denominator. Thus in, 576–A, 4–576, 1/4–576, $\frac{576}{\text{BB}}$, the size, and thus the filing drawer, of sheet number 576 is indicated in various ways. Care must be taken in selecting such a designation, not to adopt one which may be confused with that indicating revisions or issues of various dates.

In structural steel detailing, where standard sizes of sheets are the rule, no special means are taken to indicate the size of the sheet except that the "sheet number" itself is an index, not only of its size, but also of the class of material shown thereon; see explanation on p. 463. Also, for further references to this subject, see pp. 465 and 470.

A Method of Indexing and Filing Original Drawings for a Large Manufacturing Plant

The following description is taken from an article on "The Drafting-room System of the American Locomotive Co." by Mr. Fred H. Moody in "Machinery" for June, 1911. The article is valuable both for its description of a system adapted to a large and complex plant, and for the many component schemes which may profitably be adapted to the requirements of smaller offices.

General Conditions

This system was originally based on the method employed by the Baltimore and Ohio R.R. for many years in the filing of drawings, correspondence, etc. Under the Baltimore and Ohio system everything in connection with the drafting room was arranged in such a manner as to be filed along the lines of the alphabetical system to be explained in this article. The system in use by the American Locomotive Co., while originally based upon this, has changed so materially, due to the numerous improvements that have been instituted from

time to time, that it is practically a new system with nothing but the basic principle of the old system left.

The first attempt at applying this system to the American Locomotive Co. was made in 1903, just after the locomotive merger; the individual plants at first retaining their identity and carrying on their engineering staffs as before, led to much confusion in the work. It was decided in 1907 to centralize as much of the engineering work as was possible. With that object in view the Schenectady plant was selected as being the one best suited for the purpose, for not only had it the largest individual plant, but it was the most centrally located and best adapted for the purpose.

Indexing the Cards

The manner of classifying the drawings, or cards as they are called, the basis upon which this system was introduced, will first be explained. This is the principal feature of the system and is one with which slight modifications might be advantageously adopted for a wide range of work. In this scheme the parts of a locomotive are divided into 90 general groups, each group being given a number, the numbers ranging from 10 to 99; thus, group 10 is "ash pans," 11, "Axles" and so on up to 99; every part of the locomotive has a number.

As before mentioned the drawings were originally made in the works where the order was to be completed. As the system was to be uniform throughout the works, some distinguishing mark had to be given to the drawings from the different plants, so for that reason the initial letter was chosen. Thus "S" stands for Schenectady, "B" for Brooks, etc.

Originally there were nine sizes of drawings, but as the work has increased in size, that is to say, locomotive sizes have developed more rapidly than was anticipated, the company had been forced to adopt two new sizes for the erecting cards. The following table gives the number of sheet, size and the details for which each sheet is to be used:

No.	Size	Use
1	12×9	Small details and brass work.
2	12×18	Small details and brass work.
3	24×18	Details.
4	24×30	Cylinders, boiler sections, grates, ash pans and tanks.
5	12×42	Engine frames, etc., and small designs.
6	12×60	Engine frames, etc.
7	24×42	Cylinders, tender frames and tanks.
8	24×60	Boiler elevations and small erecting cards.
9	25×66	Ordinary erecting cards.
10	25×84	Double-ender erecting cards.
11	25×102	Mallet erecting cards.

This covers sizes and shapes to meet all classes of work.

The previously mentioned general groups are further subdivided. For example, the "steam pipe, etc." group 80 is subdivided into steam pipe, tee-heads, joint rings, etc. The "tee-heads" subdivision is given a series of numbers ranging from 2,000 to 3,000; joint rings, 3,000 to 4,000, etc. Each drawing when completed is given one of these numbers, say 1,000 and at the

same time all the numbers from 1,000 to 1,009 are allotted to it, permitting nine further tabulations to be made.

(For a further explanation of this scheme see below—Ed.)

Another feature of interest is the manner in which certain sized sheets are allotted to certain work; for example, "steam pipe tee-heads" can be made on sheet size number 2 only; "steam pipe joint rings" on sizes 1 and 2, etc. Experience has shown that these sizes are the best for that particular line, thereby keeping the work uniform. This classification and numbering is looked after by a special drafting-office system index which tabulates all the groups, etc., giving all the details in connection with it. The majority of drawings, however, are made on size 3, which by reference to the above table, will be seen to be the best for general purposes.

It can be seen from the explanation given that the general group number, size of drawing, works at which the drawing was made, and number of the drawing

REV SYM	DATE	INITIAL	STEAM PIPES, &C. Superheater Header Support American Locomotive Company, January, 12th 1911	803 S 71660

C	B	A	CARD	ORIGINAL SHOP ORDER NO.
			S 71660	
			S 71661	
			S 71662	
			S 71663	
			S 71664	
			S 71665	
			S 71666	
			S 71667	
			S 71668	
			S 71669	

FIG. 195.—Tracing imprint, showing method of grouping into general and sub-divisions (Am. Loco. Co.).

in that group, represent four different factors, seemingly with but little connection; it remained to combine these groupings in some simple, logical manner that they might be readily understood. An example will show what was done: Consider group 80, card size 3, Schenectady works, card number 71,660. In the system adopted this would be written as follows: 803 S 71,660. This is readily understood, the first two figures giving the general group number; the third, the size drawing; the letter, the works; and the final group of figures, the drawing number in that group. This arrangement is shown in Fig. 195 where the drawing number is placed in the upper right-hand corner.

Below, as shown, are placed the ten tabulations allotted to the drawing as previously mentioned, and opposite to it, the original shop order number. Should any dimensions be lettered, the space to the left will be ruled to suit, as indicated; however, these tabulations are usually additions.

A further explanation of this system of "sub-numbering" as given by the author (Mr. F. H. Moody) is as follows: The actual drawing

number is 803 S 71,660. This is the drawing number of the part as made on the initial order. The number of this initial order is placed in the imprinted table in the place provided. Now, in the designing of a new part, it frequently happens that an earlier designed part can be used with only one or two minor dimensional changes. Instead of making an entirely new drawing for the new part, it is the practice of the A. L. Co. to letter the dimensions that are variable (revising the tracing in case of change), and to insert the dimensions in the place provided in the imprint. The dimensions for the original are inserted in the row opposite S-71660, for the first change opposite S-71661, and so on, the order numbers being also inserted. Then for the first change the new drawing will have the number S-71661, although, to be exact, it is still the original drawing with tabulated changes. In other words, the original tracing number is only of connecting interest in the list of drawings on a particular order; but no confusion in drawing numbers need occur because the "Order No." is the "index" or "pointer" to the correct drawing for any given job.

It is possible to arrange for as many as ten forms of this design, all accommodated on the same tracing but each given a different drawing number. When the allotted number of ten spaces is filled up, the same drawing can be continued by making a Vandyke, and allotting a new drawing number series of ten numbers.

Immediately to the left of the drawing number is a space containing the name of the group and the sub-group, the company and the date. In the example, "steam pipes, etc." corresponds to 80 and "superheater header support" corresponds to the sub-grouping 71,000 in general group 80. Further to the left in the small tabulations shown, is a space to be filled in case of any future revision of the drawing. All this corner piece of the drawing is printed in the local press room so that the work is absolutely uniform. Electrotypes of the different headings and sub-headings are kept in stock, so that no mistake in giving the titles can occur.

Record Prints and Blueprint Folios

As is customary in most drafting rooms, the tracings were used for reference purposes until quite recently, when a new system of record prints was introduced. It was found that the constant handling of these tracings had a very bad effect, in many cases requiring their renewal long before it should have been necessary. Under this new scheme an extra blueprint is made from each tracing, on which, during the blueprinting process a large R, 2 in. high, is printed, with this legend directly below in good sized letters:

THIS IS THE RECORD PRINT
MUST BE TREATED AS AN ORIGINAL
RETURN TO VAULT PROMPTLY

In this way the tracings are saved; they cannot be taken from the vault except when absolutely necessary for changes, retabulating, etc. These record prints, being kept automatically up-to-date by the blueprint department, are authoritative and serve their purpose equally as well as the tracings. While additional

expense is incurred from having to make this extra print, it is more than compensated for by the diminished wear and tear on the tracing.

Further records are kept in the form of blueprint folios, which are loose-leaf books of the blueprints arranged according to their general groups and sizes. These are very convenient for the draftsman in looking over previous records of what has been done in any particular line.

Vault

The main vault has two floors containing tiers of shallow drawers in which the tracings are kept with respect to group, different sized drawers being used according to tracing sizes. These tiers of drawers are so arranged around the wall as to be conveniently gotten at by the clerks. In this vault are also kept any permanent records, such as specifications and the books for castings, patterns, cards and material. The reference prints previously mentioned are kept in tiers of drawers in a room adjoining the vault. Not being of a permanent nature, they do not require to be kept in the fireproof vault, from which they are excluded by reason of the lack of space. The card, pattern, casting and material books, are kept in the vault, arranged according to order number.

Numbering, Filing and Indexing "Outsiders'" Blueprints

The number of "outsiders'" drawings that will come into an engineering office varies very greatly with the class of work on which it is engaged. In some offices an occasional print only may be presented with the order, while in others there may be several thousand prints to be indexed, filed and disposed of on a single job. The schemes described below vary from the simplest to the most complex and will serve as suggestions to the choice of a suitable system.

With Correspondence.—Firms engaged in the manufacture of standard or semi-standard apparatus will occasionally be called upon to supply variations or specialties. The requirements are often shown on a drawing; but, as such occasions are infrequent and the "outsider's" drawing is of no further value, it will not pay to install a separate system for filing and indexing such prints. They may therefore be advantageously treated as correspondence, filed with the letter accompanying them, and not indexed at all (or at least only under the letter-indexing system). This is the method used by one of the largest pump manufacturing firms in the country, and for all such plants it is well adapted.

By Job Number.—When from about twenty to fifty drawings are regularly received from "outsiders" on each job, it is usually best to file them with the other drawings of the job and to use some system for indexing and recording them. An example of such a case occurs in structural-steel detailing offices where drawings are received from the architect or engineer. The print will be *marked with the job number* with a colored pencil in some definite place so that it may be recognized by a clerk or office boy, stamped with a dating "Received" stamp,

recorded on a form such as is shown in Figs. 199, 203, or 206, and ultimately sent out to the proper parties or filed with the other drawings of the job.

By Job and Subdivision Number.—When several hundred or thousands of drawings are frequently received on a single job, as often occurs in consulting engineers' offices, a **more extended system** than that described above is necessary in order to find any required drawing promptly. This may conveniently take the form of a **topical index with decimal subdivisions.** Several examples of such methods of classification are given in this book, see pp. 409, 415 and 449.

For a firm engaged in the design of steam-power plants, the primary divisions of the index might be Buildings, Boiler Plant, Prime-movers, etc., numbered 1, 2, 3, etc., each one subdivided on a decimal system such as: 2.0 Boiler Plant, General; 2.1 Boilers only; 2.2 Furnaces; 2.3 Economizers; etc., etc. A print from the economizer contractor on Job No. 176 would then be marked (by stencil or by colored pencil) 176-2.3 and the office boy could file it accordingly. If the drawings are filed in drawers, separate envelopes or large folders properly marked will serve to hold all the drawings of that division or subdivision, and any drawing or all drawings relating to that part of the installation can be located immediately. It is, of course, necessary that the classification be conspicuously posted and that it be understood by all having occasion to find the drawings. The avoidance of the necessity of compiling and consulting a card index referring to the prints is one of the advantages of the system; and another is that all drawings on one subject (from outside contractors, at least) are filed together. If "record prints" are taken from the original office tracings, and are similarly filed under the topical classification, then all the drawings on a job referring to a particular part of the installation may be consulted *en bloc* and immediately, and in many offices this is of great advantage.

By Consecutive Number with Card Index.—This method is described in connection with the comprehensive system of filing, indexing and recording all drawings given below. In brief, it provides for giving a consecutive number to each print as it enters the office, recording the same in a bound book and in a card index, folding to a standard size, and then filing away by the consecutive number. This scheme might, if desired, be used to record and file "outsiders'" prints *only;* original tracings being taken care of by some other system.

A Combination Method of Numbering, Filing, Indexing and Recording Original and Outsiders' Drawings[1]

In brief, this method provides for giving a number of a consecutive series to every original tracing or "outsider's" print, recording the same

[1] Published by permission of Messrs. Ford, Bacon and Davis, Engineers, New York City.

in a loose-leaf record-book and in a card index, and then filing away by consecutive number.

This system is radically different in its fundamental principles from any yet considered. It has been in use for a number of years in the office of a large firm of consulting engineers engaged principally on power-plant and street railway work and has proven very satisfactory. For such offices, and for smaller offices, it comprises a large number of important advantages. For offices which receive and transmit a very large number of outsiders' prints (say from 1,000 to 5,000 on a single job), however, some combination of "job number" systems might be more satisfactory.

Numbering the Drawings

Every drawing, whether it originates in the office or whether it comes from outside sources, bears, or is given a number of a consecutive series. Original tracings show this number in the usual place provided for it, while prints from others (called for convenience "Trade" drawings) are folded to a standard size (about 5 in. × 12 in.) and have the number written on the outside. In the case of a set of "Trade" drawings that are not liable to separate distribution, they may all be rolled or folded together and one number only used for the whole.

A system of letter-marks helps to indicate the character of the drawing and also shows where it has been filed; prefixed letters indicating the origin of the drawing and suffixed letters its size.

Thus, original tracings made in the home office bear a prefixed letter, such as "N" for New York, and a suffixed letter "A," "B," "C," etc., which indicates the *size* of the sheet; and, as all tracings of the same size are filed together, the search for the tracing in the file is narrowed.

Prints from "outsiders" are known as "Trade" prints and are given numbers with a prefixed "T."

Tracings produced in branch offices (or prints from them) are given prefixed letters indicating the office, such as "B" for Birmingham, "S" for San Francisco, etc. These drawings are numbered from "1" up, for each branch office, and, to this extent, constitute an exception to the system; this makes no difference however to the filing and indexing of these drawings as part of the system.

Maps have a suffixed letter "M" and are filed in a separate drawer, except those made in the home office.

Drawings that can best be filed in rolls, are given a suffixed letter "R" indicating that they are filed in a rack.

The following examples will illustrate the system of numbering:

"N-7849-A" indicates that the drawing of this number is a tracing made in the home office, of the "A" size (23 in. × 35 in.), filed in the "A" drawer.

"S-126-B" indicates that the drawing is a tracing (or print from

a tracing) made in the San Francisco Office, and that it will be found in the San Francisco drawer.

"T-6578-R" indicates a roll of "Trade" prints filed in the roll rack.

"T-6615" indicates a "Trade" drawing which may be found in the drawer for folded trade drawings.

"M-8765" indicates a map from an outside source, filed in the "map" drawer.

Indexing the Drawings

All drawings are indexed in a consecutively numbered loose-leaf **"Record-book"** and in a card index. The heading of the Record-book sheets is given in Fig. 196 and its use will be obvious on examination. The sheets are about 12 in. high $\times$ 15 in. wide; the numbers are put in, in advance, with a numbering stamp, and about ten lines are allowed for each number. It will be seen that the movement of prints can be recorded as well as the data of the tracing itself.

Drawing No.	Title or description	Date filed	Sent out	Sent to

FIG. 196.—Heading for drawing-record book.

A great amount of reliance is placed upon the **Card Index.** It is, therefore, very carefully made, records being copiously cross-indexed. Two separate indexes are kept, the "Subject Index" and the "Client Index," each being properly subdivided. The cards are of the 3 in. $\times$ 5 in. size, usually one drawing only being recorded on a single card. Each card bears, in a prominent place, the consecutive drawing number with its prefixed and suffixed letters, the date, title, etc., and, in the case of a trade print, any designating marks and numbers. As this index is practically the only guide to the location of a drawing, great care is taken to have it properly made and kept up to date, one man alone, an expert, devoting his entire time to the recording and filing of the drawings, and the compilation of the index.

This index answers another purpose, and one hardly less valuable than its primary function of locating drawings. This is its service as a library (or topical index to a library) of technical information. A glance at the cards under the heading of "Street Car Trucks," for example, shows immediately all the drawings of this detail that are in the office, whether original or "outsiders." If the index is made up in such a way as to take care of the prominent details on a drawing (whether indicated in the title or not) its usefulness in this respect is many times enhanced. (See p. 472.)

In the case of drawings (tracings or their prints) from branch offices, a separate loose-leaf "Record-Book" is kept with a section therein for each, as each office starts numbering its drawings at "1." The card index classifies these drawings in the regular way under the "subject" and "client" indexes; but it is usually found convenient also to make extra cards for these drawings and to file them under the name of the branch office.

Filing the Drawings

Original tracings are filed flat in drawers, all tracings, of each size ("A," "B," or "C") in the same drawer. In the drawers they are filed by their consecutive number.

"Trade" drawings are folded to a template (about 5 in. × 12 in., depending on the dimensions of the drawer) and are filed in numerical order in stacks in the drawers. The alignment in the drawer may be preserved by tying the stacks into bundles with tape. In the case of large rolls of "trade" drawings which are not liable to have the individual drawings removed, one number is given the whole and it is filed in a numbered rack or pigeon-hole; such a roll would bear a number similar to "T-6042-R," the "T" showing that it was a "Trade" drawing or drawings, and the "R" that it was a roll and was filed in the roll rack.

Maps, as issued by the U. S. Geological Survey, are filed separately by states, and arranged alphabetically according to name of sheet.

Cross-indexing Special Drawings for Designs of Probable Future Usefulness

The original drawings produced in a consulting engineer's office will be of two classes, those special to the job, and "standard" drawings that may be used on a number of different jobs. The same conditions will also occur in the office of a general manufacturing concern.

The filing and indexing of the "standard" drawings is an easy matter, they may be filed either numerically or topically in special drawers, and a "Miscellaneous" card-index file based on an alphabetical or topical classification (or a combination of both) will secure quick finding of any drawing.

It will usually happen, however, that drawings special to the job will contain designs that may be useful on future work. Mr. A., for instance, may remember that some years ago a design was made specially for some client whose name he has forgotten; or, again, a new office force may wish to know whether a certain problem has ever been attacked in the office before, and how. Assuming that the drawings have all been filed away under the job name or number, the only way of keeping

track of these problematically useful designs is by some system of indexing. A card or a loose-leaf system may be used as preferred, the data being filed alphabetically or topically; the card system is, perhaps, of the most general utility. A sample card is given in Fig. 197.

It should be the duty of some competent man to inspect all special drawings at convenient intervals, taking note of any designs or schemes that may appear to have possible future usefulness, and to record these features in the manner shown on the card. In a large office, or in one that has prospect of future enlargement, such an index becomes a matter of absolute necessity for successful operation.

In the example illustrated, two cards should be made out, one to be filed under "S" (for seal) and one under "T" (for Tank), so as to be quickly found by persons of different mental processes, or by the same person whose "location sense" may vary at different times; or, better, the card may be filed under "T" and a cross-reference card put under "S," good for all Seal Tanks.

Name. Seal Tank for last cell of an Evaporator

Job No 176 *Drwg. No.* 2104 *Date* Jan. 21, 1909

Remarks: Placed inside large sweet-water tank to ensure seal when large tank is drained.

FIG. 197.—Card for cross-referencing drawings.

SEC. II. DRAWING MOVEMENT RECORDS, ETC.

DRAWING MOVEMENT RECORDS

In any engineering drawing office some method must be adopted by which the movement of original drawings, outsiders' drawings, original specifications, and, sometimes, shipping lists may be recorded and traced.

To accomplish this, blank printed forms are usually used, properly prepared so as to produce a system that will reduce errors of omission or commission to a minimum. The forms given below have been in use in a general engineering office for a number of years, and have been found to answer their purpose satisfactorily. They are based on a form used by the American Bridge Co., but differ from the latter in that four small sheets are used, whereas the A. B. Co. uses one large sheet. The large sheet has the advantage that more information can be obtained at a glance, but the small sheets are better adapted to filing in a standard invoice file. The smaller sheets also allow for the insertion of more data than can be conveniently placed on one large sheet of practicable size.

The sheets may be punched and held at the end in a convenient

folder; or, for small jobs, secured by ordinary clips. This "loose-leaf" method allows additional sheets to be added as required, and also (on large jobs) allows for the use of a system of index tabs. When the contract is completed, the record may be filed with the other data in an ordinary invoice file.

(1) **Recording Original Drawings.**—The form shown by Fig. 198 is intended to take care of prints made from tracings prepared in the home office. Its use will be evident from an inspection of the headings. If care is taken to see that all tracings are recorded as soon as made (or other device adopted to secure this end), it will hardly happen that prints from any tracing will be forgotten.

The "Tracing Revised" heading is intended to record the date on which the tracing was revised and given the suffix letter "A," "B" and "C" for the first, second and third revision. Here, again, an inspection of the record at intervals will indicate whether revised prints have been properly issued. When prints have been receipted for (see p. 485) a blue "check" mark opposite the date of issuance is a convenient method of indicating the fact; and absence of this blue "check" mark after a proper interval would indicate the desirability of issuing extra prints or tracing the first shipment.

(2) **Recording "Outsiders'" Drawings.**—These are drawings received from contractors, other engineers and branch offices, relating to the contract. On most jobs they will far outnumber those prepared in the home office. They will include drawings sent in for approval, erection drawings that must be forwarded to the owner or erector, detail drawings of apparatus required by the engineer for his own use or to collaborate with others, etc., etc. In all cases a proper disposal of these drawings is imperative for the successful progress of a job. The form given in Fig. 199 was prepared with all these contingencies in view. The headings are self-explanatory; and as the whole progress of a drawing is taken care of on one line of the record, an inspection of the sheet at intervals should ensure the proper routing of these "outside" drawings and obviate forgetfulness of their intended disposal.

(3) **Recording Original Specifications.**—The form shown on Fig. 200 is of the same general type as those preceding it and is used in the same manner. It applies to the specifications originating in the engineering office, and furnishes a complete record of their progress.

(4) **Recording Shipping Lists.**—As explained in a previous chapter (p. 330), shipping lists for domestic movements of freight are usually extremely brief, and in many cases are not furnished by the shipper at all. They are not of vital importance for material intended for installation in the country of origin, and consequently there is no particular necessity for keeping any other record in the engineering office than a mere notice of shipment.

On export work, and to engineers engaged on material for foreign installations, however, the matter of obtaining completely detailed shipping lists and suitably recording the same is of the first importance.

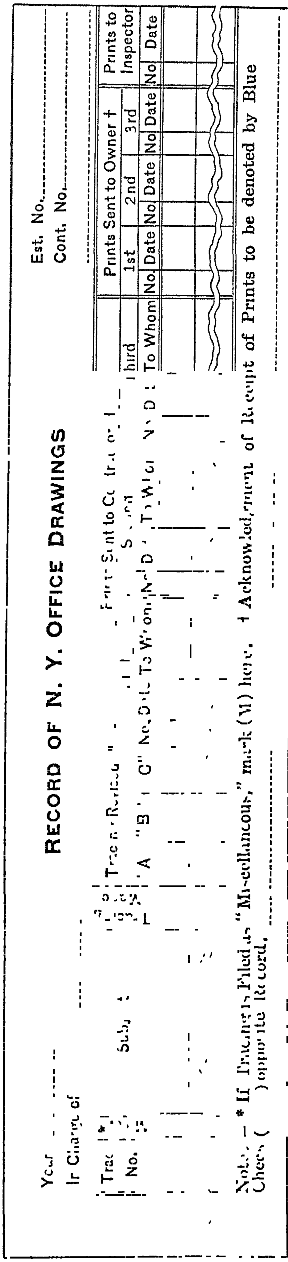


FIG. 198.—Form for recording original drawing movements. (Sheet measures 8 in deep × 12 1/2 in. wide.)

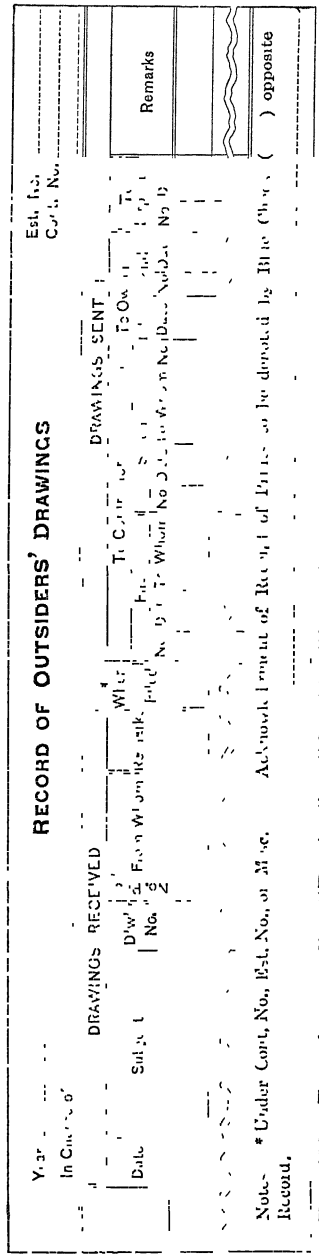


FIG. 199.—Form for recording "Foreign" or "Outsiders" drawing movements. (Size, 8 in. deep × 12 1/2 in. wide.)

A typical sample of an export shipping list is given on p. 359, and in Fig. 201 is shown a record sheet suitable for binding with the office

records given in the three previous tables. A compact record of shipments such as can be kept on these sheets will usually be found of great utility in giving quick information on the job in question; and, particularly, such records are a great aid to the compilation of estimates of shipments and freight charges when estimating and quoting on material for foreign delivery (see remarks on p. 356).

The example shown will serve to illustrate the method of keeping the record.

The "Package Rate" indicates the weight classification of each piece, which determines the rate at which it is assessed (see typical schedule on p. 357).

The column headed (1), "Weight at 40 cu. ft. = 1 ton," is obtained by multiplying the number of cubic feet (given in the previous column) by 50; and may be called the "measurement weight." Columns (2) and (3), as also the "cubic foot" figures, are simply compiled from the shipping list. The "addition for measurement," or the difference of col. (1) over col. (3), represents the extra amount that will have to be paid for on account of the bulkiness of the piece (see p. 356). The column "1 ÷ 3" gives the same thing in ratio form. For heavy, "chunky" pieces, charged for by weight, there will be no entry in these last two columns, as they would be respectively negative figures and figures less than unity; and, as the steamship company always charges for the worst case, these figures could not be allowed to deduct from the additions for measurement. In order to complete the equation, however, the (1) column must be filled in with the "gross weight."

The single final figure, for which all these figures are prepared is the quantity 2.23 in the example, which tells us that for a machine similar to the one tabulated, about 2 1/4 times the gross weight will have to be paid for when figuring the freight charge, on account of the bulkiness of the pieces comprising the shipment.

This final ratio is sufficiently accurate, however, only when used as part of a large shipment. For the shipment of a single machine, each line of the above record should be taken and the freight charge figured for both weight and measurement, the greatest being selected in each case. See p. 357 for example of difference in rates due to weight and size of individual pieces.

Structural-steel Detailing Office Records

The characteristic feature of structural-steel detailing office work, from a record-keeping and filing point of view, is the fact that, in the great majority of cases, a job can be started, carried forward and definitely closed within a comparatively short space of time. Furthermore, drawings and other information from outside parties form a small

proportion of the records. For this reason, therefore, it is often unnecessary to keep records of "outsiders'" drawings except by the regular

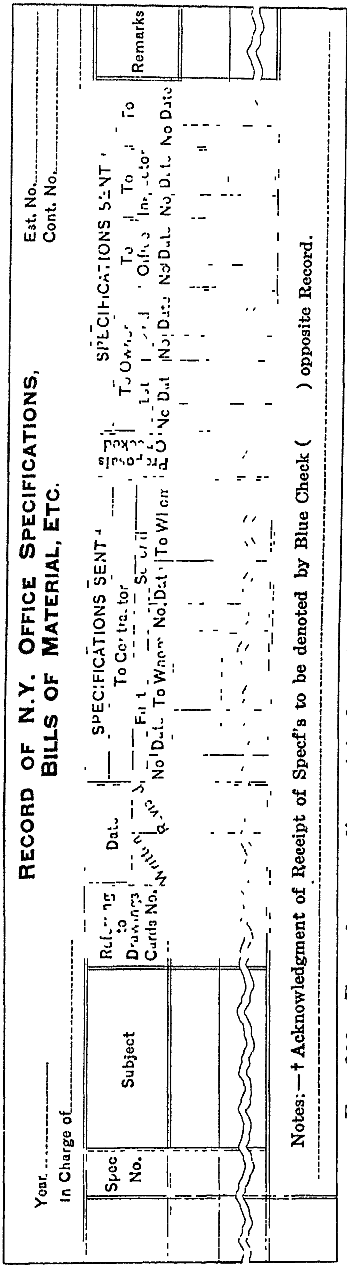


FIG. 200.—Form for recording original specifications. (Size, 8 in. deep × 12 1/2 in. wide.)

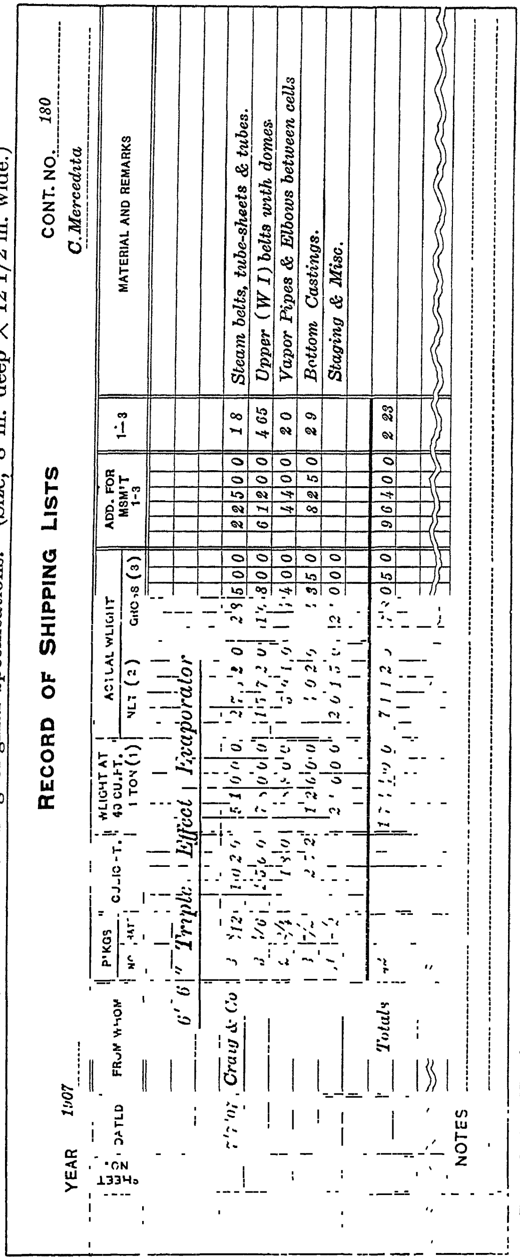


FIG. 201.—Typical record sheet for shipping weights (export particularly). (Size 8 in. deep × 12 1/2 in. wide.)

correspondence relating to the job, and a record of the drawings and shop bills originating in the detailing office is all that is necessary. A

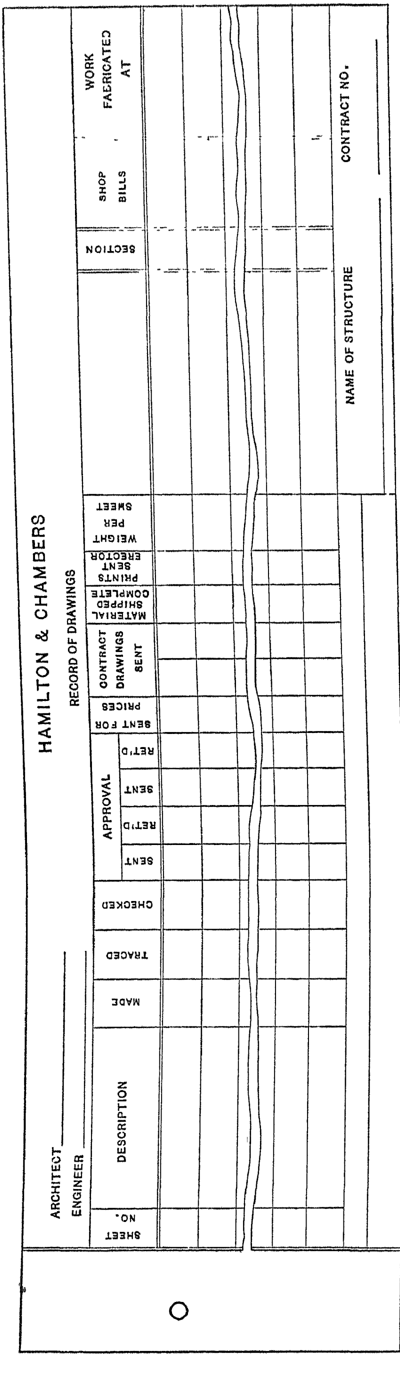


FIG. 202.—Form for recording original drawings of a structural steel detailing office.

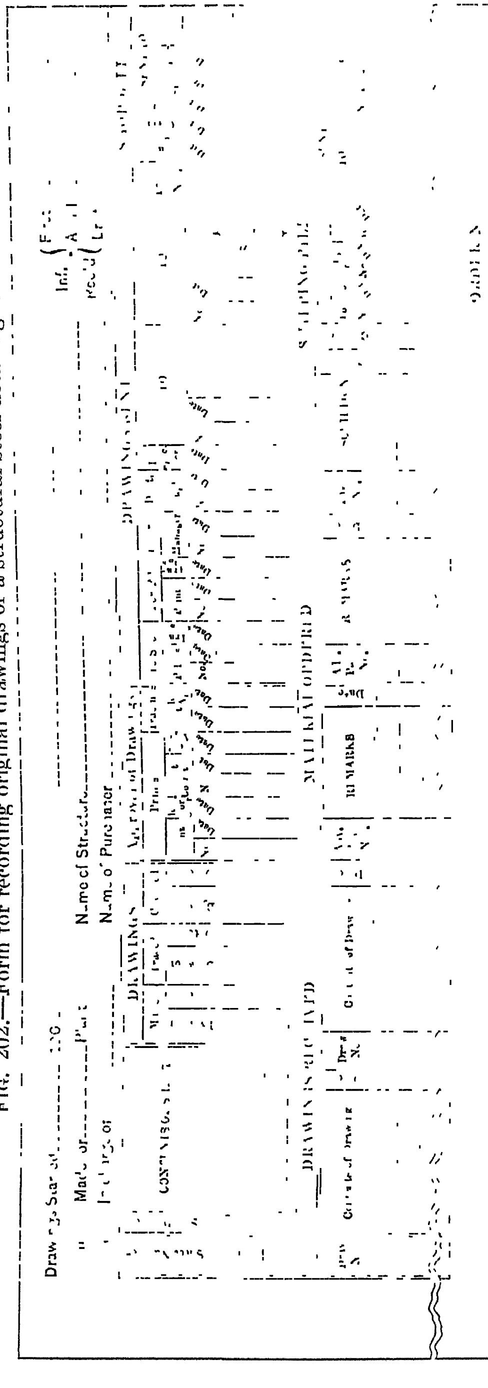


FIG. 203.—More complete form for structural steel detailing office records. (Size 17 in. wide × 14 in. deep.)

blank sheet for such use is illustrated by Fig. 202. These sheets can be bound at the edge by regular loose-leaf methods, and, on completion of the job, can be conveniently filed.

If, however, it is desired to record drawings received from the architect or engineer, and other information relating to the job, a form such as is shown by Fig. 203 may be used.

A System for Keeping Print Records on the Original Tracing

In the "Engineering Magazine" for July, 1913, is an article entitled "A Simple System for Filing and Handling Tracings and Prints" by Mr. Fred Buch, which, the author states, embodies the results of "a careful and exhaustive study of drafting-room filing and recording methods in many offices, both large and small, with the object of developing a system that would not only reduce routing work to a minimum, but would be so simple to follow out that no attention need be given to details, all filing work being attended to automatically by the various persons directly connected with the same without loss of time, and without distracting their attention from their work."

A very complete exposition is given of a drawing-office system, but only the salient feature of it, or the method of keeping as much information as possible on the original tracing itself, and thus doing away with separate record-books, is described (in abbreviated form) in this article.

Size and Arrangement of Tracings

To secure the usual advantages, uniformity in size of tracings is adopted; all being of a width to cut from 30-in. cloth. A "full length," or 36-in. sheet, is shown in Fig. 204; the "half-length," or 18-in. sheet, has identical lining except that the working space is 18 in. instead of 36 in.: for special work longer lengths are sometimes, although rarely, used. The standard size sheets are bought already cut and printed, this being found to be economical. The width of margin, etc., has been carefully selected for practicability and economy.

It will be seen that 6 in. at the right-hand end of the tracing is reserved for title, notes, reference plans, etc. In Fig. 204 the use of the spaces is only referred to, actually they are tabled as described or illustrated below. One general and great advantage of this uniformity in noting and recording is, of course, that such notes or records are always in the same place on every drawing, so that there is no excuse for anyone looking anywhere else for them, nor for the draftsman forgetting to put them in. The printing is done on the *reverse* side of the cloth, so as not to be smudged or to be interfered with by erasures.

Title

The form for the title is not reproduced here. The original article describes a method of title-writing on a "Classification, Division and

Description" system; but any desired form of title could, of course, be used. In this space, also, is placed the "drawing" and "issue" number; the former, in this case, being one of a consecutive series. The "issue" number is one used to indicate revisions, 1, 2, 3, etc.; it is put in in pencil so that it can be readily changed every time the drawing is revised; it bears an important relation to the "Tracing and print record" described later.

Notes

This space is reserved for the usual general and special notes applying to the drawing.

Reference Plans

This space is ruled, and is tabled under headings "Classification; Title; File No.," suitable for reference to any related plans. Such references are often extremely useful and time-saving.

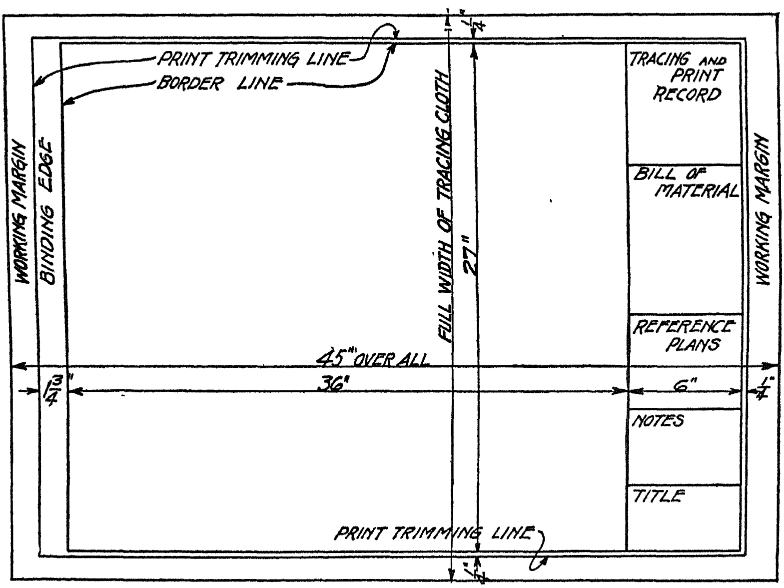


FIG. 204.—"Full length" tracing sheet.

Bill of Material

The ruling of this space is not reproduced here: it may follow any of the usual forms.

Tracing and Print Record

The example of this record is shown in Fig. 205; and the following extract describes its use.

"The tracing and print record, Fig. 205, which occupies a space 6 × 6 1/2 in. in the upper right-hand corner of the plan, gives a complete key at all times to

all that has been done on the tracing. The draftsman, after completing the title as described in the foregoing paragraph enters under issue number 1 the date on which he is starting the plan, and his name or initials, and then proceeds with the actual work of drawing. The man inking in the plan or tracing it enters his signature under the same issue number opposite "Traced by," and the plan then passed to the checker who checks the same, has all necessary additions or cor-

TRACING AND PRINT RECORD												
ISSUE NUMBER OF PLAN	1	2	3	4	5	6	7	8	9	10	11	12
DATE	1-12-13	3-15-13	3-18-13									
DRAWN BY	F. M.	F.M.	FM									
TRACED BY	S. R.	F.M.	FM									
CHECKED BY		M.W.	M.W									
APPROVED BY		M.R.H	M.R.H									
LIST OF CHANGES AND ADDITIONS		MINOR CHANGES DUE TO CHECKING	ADDED DETAILS OF STAIRS AND HANDRAILS — ADDED 2 LINTELS, ON BILL OF MAT'RL (ITEM - 4)									
PRINTS SENT OUT: ~~Am. B. Co. New York~~	2 3/13											
N. R. Iron Works	2 3/13	2 3/16	2 3/19									
~~Con. Br. Co.~~	2 3/13											
~~Beth. S. Wks~~	2 3/13											
~~Eastern B. & S. Co. Boston~~	2 3/13											
~~Berlin Const. Co~~	2 3/13											
A. M. W.	2 3/13	2 3/16	2 3/19									

FIG. 205.—Tracing and print record, in the upper right-hand corner of plan. On this record is kept a complete account of all changes and additions made to both plan and bill of material, dates and numbers of prints sent out and addresses to which they are sent.

rections made, and, having satisfied himself of the correctness of the plan, enters his initials opposite "Checked by" and hands it to the engineer in charge, who may or may not approve the plan, as he sees fit. If prints are to be made and sent out, instead of making out a print order on paper, the engineer enters the addresses or names of those to receive copies and the number of copies each is to get directly on the tracing as shown under "Prints sent out" and then sends the

tracing to the blueprint clerk who produces and mails the prints, entering the date of mailing when he inserts the prints in the various envelopes. The date of mailing thus serves as a check to show the prints were actually sent out. A further check to insure the prints reaching their destination is described in this article under "Mailing Prints," but has no connection with the "tracing and print record."

"A glance at Fig. 205 will now show us that the plan was started Jan. 12, 1913. It was drawn by F. M. and traced by S. R. but copies were evidently sent out for bids in a hurry as no time was allowed for checking and consequently it could not be approved. Two copies each were sent to seven addresses and the print clerk forwarded them 3/13 as shown from the record. Thus we have the whole history complete without the slightest duplication of work or loss of time, and the system is so simple that there is no excuse for a mistake or error.

"The addresses serving as print orders in the "Prints sent out" space should be written with blue ink or ordinary writing fluid, as this does not print and therefore cannot be read on the blueprints, the idea being that it might lead to embarrassment if the competing concerns were revealed to each other."

"The tracing and print record shown in Fig. 205 gives the complete history of the plan up to and including issue No. 3. The plan was started Jan. 12, 1913, by F. M. and traced by S. R., but prints were not sent out until 3/13 when they were sent to six parties for bids, and to the client. Minor changes, due to checking and pointed out on the prints by the hand with the "2," were made 3/15 and the print was then checked and approved and two copies each sent to the contractor and the client 3/16, or March 16. Stairs and ladders, and two lintels (item 4) were added 3/18 by F. M. and these changes were checked and approved and 2 copies each sent to the same parties on 3/19 and these parties were able to follow the changes without any further instructions.

"It will be noticed that only two of the seven addresses listed received copies of Issues 2 and 3, these being the bidder and the client. To get copies to the right parties only, the engineer in charge of the work and therefore familiar with these conditions simply crosses off the addresses not desired. Should some of them reenter the race (which is not likely after the contract has once been awarded) the name is repeated in another space as it then takes the place of a new concern, or new address."

Revising a Plan

"The first copy of a plan is always Issue No. 1.

"Should additions or changes be made on the plan after it has once been officially used and therefore become a matter of record, the issue number of the plan changes with each revision and becomes 2, 3, etc. The draftsman puts down under Issue 2 the date of the revision and, opposite the words "Drawn by," his initials. He then makes the desired additions or changes to the plan, stamping a small hand opposite each such addition or change, the index-finger of the hand pointing to the same. In the palm of each such hand he prints a figure 2 to correspond with the issue number 2, thus pointing out to even the most uninitiated what the changes or additions consist of in this issue. This is now supplemented by briefly listing these changes in the Tracing and Print Record under Issue 2, and thus we have a very complete record of all that has been done.

"Having completed the work of revising the plan, the issue number after the drawing file number in the lower right-hand corner of the title stamp is changed to agree with the other issue numbers. This latter number serves as a check, and indicates at a glance to the engineer, bidder, contractor, or client the latest number of the plan. It is therefore entered in pencil only, is always changed last, and must always correspond with the latest issue number in the Tracing and Print Record."

Card Index

The drawings may be card-indexed under job number, subject, etc., in any of the usual ways, so that they may be readily located when required.

A Simple System for Recording "Foreign" Print Movements

This system[1] consists, in brief, of recording on the office-record print the disposal of the other copies.

When prints arrive from other parties (so called "foreign" prints), they are stamped on the back by the mail clerk with a form such as is shown in Fig. 206, and passed on to the engineer in charge. After inspection and approval, the latter fills in the form on *one print only* and returns the set to the file clerk who fills in the upper and middle sections of the other prints to correspond with that marked by the engineer. The file clerk also marks on the *front* of each print, in red pencil, the case, drawer, job, drawing number, etc., according to whatever system of indexing may be in use in the office.

Received
No of Copies
From.

Job
Classif
Division
Title
Approved

Copies Sent Out

No.	To	Date

Fig. 206.—Stamp for recording "Foreign" print movements.

"On the lower portion of the stamp is designated to whom copies are to be sent and how many. To save unnecessary work only one print is filled out with this information (by the engineer) and this print becomes the office copy, not to be sent out. The prints to be sent out are forwarded immediately, accompanied by a self-addressed return postal, to make sure they reach their destination. They are mailed or sent out as soon as possible to prevent their getting into the office files and crowding these unnecessarily."

In the case of revised prints received from others, a system of revision-records may be kept if desired, but a simpler way is to paste:

[1] Eng. Mag., July, 1913, see Ref on p. 479.

"Old and new prints together along one edge only, the latest print on top, and thus if it is desired to have a record of all the prints received of one specific article or unit, they will be found in the files fastened together in the order received and changes or alterations can be traced from print to print in a twinkling without undue effort, and by turning over these office copies a glance will tell who received copies of the same, how many, and when."

Drawing No. . . . . . . Date. . . . .
Case. . . . .
Drawer . . . .
Charge to . . . .

FIG. 207.—Drawing receipt card.

KEEPING ACCOUNT OF TRACINGS AND PRINTS IN THE OFFICE

In the larger offices, tracings and prints are usually kept in the care of a special department whose business it is to properly file them

BLUE PRINT ORDER.

NO. WANTED	DRAWING NUMBER.	TITLE OR DESCRIPTION.

Mailing Address, ...

....

MARK TO SHOW DESTINATION OF PRINT.

ORDER RECD. BY B. P. DEPT.	PRINTS WANTED BY
.... O'CLOCK	.... O'CLOCK

DELIVER PRINT TO. ....

RETURN TRACING TO ....

Charge to Job or Order: ....

Signed..

Dated ....

FIG. 208.—Blueprint order form.

(usually in a vault), and to issue them only on written authority. The engineer or draftsman desiring a drawing, whether tracing or "foreign"

print, ascertains its number from whatever index may be in use and fills out a card, which may be of some such style as is shown in Fig. 207, and hands it to the file clerk.

As the print is issued, the card is inserted in a suitable clip in the drawer and a record is thus preserved of the location of every tracing or print that leaves the files. By checking-up on these cards once or twice a week, the filing department can practically ensure against the temporary or total loss of any drawing. On replacement of the drawing, of course, the card is withdrawn and returned to the originator.

A blueprint order-form of a type to either, (1) direct mailing of prints to others, or, (2) to obtain for office use, is shown by Fig. 208.

Obtaining Receipt for Blueprints

It is always desirable, and is frequently of the utmost importance, that prompt and certain acknowledgment be obtained for the receipt

SW-154 10m 9-17-12

Schenectady N. Y., ____________ *191* ____

GENTLEMEN

We have this day sent you by mail the following Blueprints;

DRAWING No.	BY AUTHORITY OF

DRAFTING DEPARTMENT, per J H BOSTOCK

Received ________________________________ *191* ___

PLEASE SIGN AND RETURN IMMEDIATELY

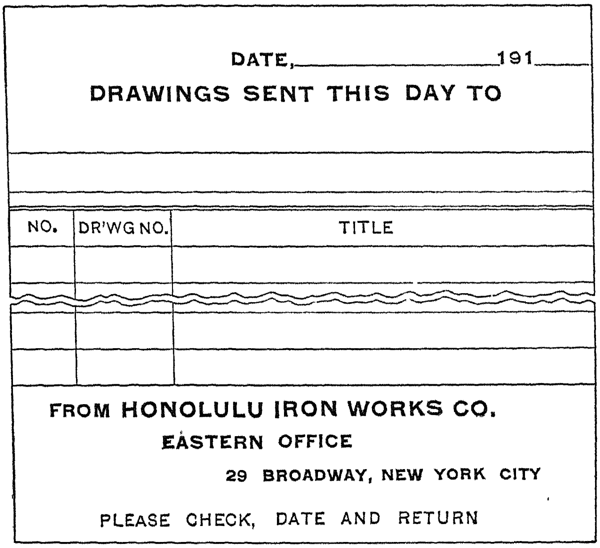
Fig. 209.—Receipting post card for blueprints.

of blueprints sent to engineers, erectors, and other parties requiring them. Such acknowledgment is best obtained by means of a post card or printed slip identifying the drawings, and requiring simply to be receipted and returned to the sender. Without such easy means of receipting for drawings, the majority of engineers, foremen and owners will not send formal acknowledgment.

An example of a receipting post card is given by Fig. 209; the reverse (stamp) side has printed on it the address of the firm issuing the

blueprints. It should be noted that this type of card must either be enclosed in a letter, or with the prints in case they are sent by *first-class mail;* it is not allowable to enclose a card with prints sent by third-class mail. So that, in the more usual case where the prints are forwarded directly from the blueprint room by third-class mail, the latter department should send out a "return post card," the "reply" part of which is exactly similar to the single card described above, and the "sending" part containing on the reverse side an advice to "Please sign the accompanying card, detach and return immediately."

The above method is about the simplest that can be devised for domestic use, but it is not applicable in the case of prints sent abroad



DATE, ____________ 191 ____

DRAWINGS SENT THIS DAY TO

NO.	DR'WG NO.	TITLE

FROM HONOLULU IRON WORKS CO.
EASTERN OFFICE
29 BROADWAY, NEW YORK CITY

PLEASE CHECK, DATE AND RETURN

Fig. 210.—Receipt slip for blueprints.

because the stamped cards are of no use at the other end, unless, indeed, the volume of business be such as to warrant the purchase and printing of the foreign post cards. For export work, therefore, the use of some type of printed "receipt slip" is desirable; it may be in the form of the above post card, or similar to that shown in Fig. 210. The slips are enclosed with the letter of advice, and they form a valuable check on the safe delivery of the prints which are usually sent in a separate package, either by third-class mail, express, freight, etc.

SEC. III. MISCELLANEOUS DRAWING-OFFICE RECORDS

Pattern Records

In order to utilize old patterns as much as possible, and to avoid designing over and over again substantially similar castings, records

must be kept in the drawing office which will enable the draftsman to find out with certainty, and in a few minutes time, whether a pattern is in stock which may be utilized, with, perhaps, some slight alterations.

Two records are necessary for this purpose, a "register" or record of the patterns by their (consecutive) numbers, and a card index arranged on an alphabetical or topical basis.

The first record, bearing complete information at each entry and being added to only by consecutive number, should be kept in a bound

Patt No	Descriptive	Drawing		Material	Altered	
		No	Date		from	to
261	Center B'r Grate Bar	3471	May 23, 1912	C I		
262	Footstep Bearing	3475	May 27, 1912	Brass	155	
263	30-in. Disch. Gate Body	3481	June 2, 1912	C I	216	301
264						

FIG. 211.—Sheet from pattern record book.

book (see p. 419). A sample sheet from such a book is shown in Fig. 211.

A study of the above will show that a new number is given to a pattern every time a change is made on it. If a "repeat order" comes in which necessitates the use of the old pattern, a consultation of the original drawing will show what changes have been made and how the old casting is to be reproduced. Bearing this contingency in mind, it is desirable to make only such changes in a pattern as will be in the nature of an addition, pieces that can be tacked on and afterward removed, or making cuts that can be filled back again if necessary.

Name. Gate, Body, Vacuum Pan Discharge.		
Size. 30 in.		
Description. 45° Hinged Type, Molasses outlet, Cut-over, and Washout Connections.		
		Material. C.I
Patt No. 216	Drwg. No. 2390	Date. Dec. 12, 1911.
Remarks. Stock Pattern; see Record for alterations.		

FIG. 212.—Sample card of pattern record index.

The other record, or card index, is intended to show the draftsman almost immediately what patterns are on hand similar to the one he has in mind. The cards, therefore, should be conveniently arranged in the file, and should give sufficient leading information so that the consultant can tell whether it is worth while looking up the drawing on which the casting is detailed. An example of such a card is given in Fig. 212.

For such standard items as pulleys, pillow-blocks, etc., printed blank cards may be used; see Fig. 213.

The cards may be filed alphabetically or according to some topical system, cross indexed, if desirable, in the usual manner.

Pulleys						Dia.
Face		Hub		Arms		Weight
Width	Style	Dia.	Length	No	Style	
Patt. No. Remarks.		Drwg No.		Date.		

FIG. 213.—Sample card of index for standard material.

SKETCH SHEETS

In cases where a sketch is required to illustrate a letter, or where the matter to be shown is not of sufficient importance to warrant a regular tracing, a pencil drawing on a "sketch sheet" will often answer every purpose.

"Sketch Sheets" may be of letter or invoice size (the latter being of the greatest utility), and may be of plain bond paper, or with "cross-section" ruling of 1/4-in. spaces. The printed heading may consist of the designation "Sketch Sheet" and the name and address of the company, and at the bottom may be spaces for the Job No., For Whom, Title, Scale, Made by, and Date. They may be conveniently bound into pads.

The sketch may be made in indelible pencil and as many copies as desired obtained on some style of copying machine; or, if this is not available, several copies may be secured by using carbon papers; or, by still another method, the sketch may be made in drawing ink and blueprints made from it. In addition to their usefulness for minor detail work, they may also be adapted for supplying copies of stress sheets, small bridge outlines, etc., to owners or engineers, by simply going over the original calculations made on them with an indelible pencil, leaving out immaterial calculations, etc.

With regard to the numbering and filing of these sheets, practice differs; some firms give numbers to the sketches just as to tracings, etc.; but it would seem to be the best plan, in general, to treat them exactly as is the correspondence, pinning them to the letter they illustrate and referring to them always by date, just as is a letter. An additional copy or copies may, of course, be marked with a file number so that they may be readily found under the topic or job; and one great utility of the sketch

sheet lies in the fact that it may so conveniently be made self-numbering and self-indexing, avoiding the more cumbersome records necessary in the case of the regular tracings.

Computation Records

Computations or calculations made on designs or estimates will generally be recorded either in bound books or on loose-leaf sheets. The choice of method will depend upon the work recorded and the filing system that may be in use in the office; the advantages and disadvantages of each are considered in Chapter XI.

The following is an outline of a system for keeping calculations in **bound books.** Every draftsman or engineer is provided with a blank "Calculation Book" which is marked on the cover with his name, date begun, date completed, and a number (of a consecutive series). Ordinary paper-covered, plain-ruled, 8 in. × 10 in., 100-page books are suitable, but the pages must be numbered. The first page is reserved for an index, and the user is instructed to always head his calculations with the job number and name, character of calculation and the date, and to record the same, also, in the index, giving the page number. When the book is completed, the index is copied into a "Calculation Record" book, and a new blank book is issued to the engineer. The "Calculation Record" book may be a 5 in. × 8 in. stiff-cover, plain-ruled book in which is recorded: (1) the book number, (2) to whom issued, (3) date issued, (4) date completed, and (5) a record of the calculations therein contained, abbreviated from the index above mentioned. The left-hand page may be used for the name and dates, and the right-hand for the record of calculations, two books being recorded on a double page.

With this "Calculation Record" book on hand, it is a fairly easy matter to ascertain in what book a desired calculation was made, for the dates run approximately consecutively, the names of the calculators are prominent, and the job number under which the calculation was made is also indicated, and will also be in approximately consecutive order. The system has the advantage that calculations are not liable to be lost, as they might be if made on loose leaves; but it will be noted that a certain amount of dependence is placed, when looking up old calculations, on convenient estimate and contract records.

The **loose-leaf system,** of course, has for its object the bringing together in one place of all calculations on a certain job by whomever or at whatever time they happen to have been made, and, on certain classes of work, the advantage thus gained is paramount. The sheets may be filed according to "job No." in a separate loose-leaf binder known as a "Calculation Book;" or they can be filed with the other records of

the job, *i.e.*, correspondence, specifications, etc. Still another method of filing the loose sheets would be under a "Subject Classification," so that all calculations on, for example, "Power required for operating belt-driven centrifugals" would be found in the same file, irrespective of the job on which the calculation was made. Such a classification would have to be logically arranged, and this part of the system should be the subject of very careful study (see Chapter XI). A further advantage of the loose-leaf method of recording and filing calculations is that, in general, a separate index may be dispensed with, as the sheets will be self-filing.

For a description of the appliances of loose-leaf methods, see p. 422 *et seq.*

For a very complete general and detailed description of a method of indexing and filing engineering computations, as devised for and employed by the Filtration Department of the Commission on Additional Water Supply of New York City, and afterward developed by the author in his consulting practice, see "Engineering News" for Jan. 8, 1914, p. 78; 6 p., ill., "Indexing and Filing Engineering Computations," by John H. Gregory. The loose-leaf system is used, with the Dewey Decimal System for indexing purposes.

Photographs

Photographs are used in engineering work, (1) for giving general and detailed information concerning sites, construction, machinery, etc.; (2) to obtain small-size editions of large drawings, and (3) for survey work. The last-named use is now a branch of regular surveying practice, and will not be considered here.

Advantages of Photographic Records

They are useful when designing alterations or extensions to existing structures.

They often serve to clear up obscure portions of a map.

Photographs of a building site, and of the horizon therefrom, are a great aid to the design of structures, being the next best thing to being on the ground itself.

On construction work they show at a glance the progress of the work, to the avoidance of misrepresentation thereof.

In case of lawsuits or claims, their testimony, systematically presented, may be of great value.

Sizes

For construction-record work, 6 1/2 in. × 8 1/2 in. plates or films are recommended; for reconnaissance work, 4 in. × 5 in. or similar size; or, for the latter purpose more particularly, small-size cameras of superior construction may be used, the pictures being later enlarged.

Indexing and Filing Negatives

Any convenient system of indexing the negatives may be used, but the "consecutive number" method (p. 461), wherein each negative bears a number of consecutive series, is of the greatest general utility. In cases where photographs are made and developed at branch offices, such negatives may start a new series preceded by a letter indicating the branch office.

Each negative should be marked in the lower right-hand corner with its number, subject, location and date, in a position so as not to be so obscured or removed when the print is trimmed and mounted.

For filing, each negative may be placed in a suitable envelope with a printed information form on the back. For construction work, a suitable form[1] is shown in Fig. 214.

Accession No.. .. . .Serial No. ....
Name of Dept.... ... ...
or Work..... ... .
. . ..
Name of Contractor . ...
Date of Contract... . ...
Hour.... .....M .. Weather . ... .
Camera, kind, size. ....
Lens, kind, size ....
Plate... ... . ..Stop No. .. . Exposure . .
Subject. . . . .
....
Taken by. ... . Address... . . . .. .
Developer . ...
Printing, for Velox.. . per..... in. . min . sec. . ...

FIG. 214.—Information form for negative-filing envelope.

The negatives may be filed in a regular document file or in a box by serial number.

An index or indexes should be made, under any classification that may be necessary. For small offices, however, if albums of views are kept with the prints arranged in some logical order, the album itself may constitute a sufficient index.

Prints

Velox prints are usually preferred for general use, blueprints for minor work.

Prints may be mounted in bound albums, or, preferably, in loose-leaf binders. They may be compiled by job number, class of material, etc., as preferred, a systematic arrangement, as explained above, obviating the need, in small offices, of a card index. For systems of indexing and filing see elsewhere in this chapter, and in Chapter XI.

[1] Eng. News, June 29, 1911.

Photographic Reduction of Drawings

Photographs of drawings, made on a reduced scale, are useful for superintendents of erection or others engaged on extensive works, for storing in safe-deposit vaults, or for any other purposes where the information on the cumbersome original is required to be preserved in compact form.

In making tracings that may have to be so copied, the usual rules for preparing drawings for photographic reproduction should be followed; that is to say, details must be bold and open, lines well separated one from another, and, above all, lettering and descriptive symbols must be readily legible.

The "Photo-print" process now in use, by which tracings, blueprints, paper drawings, etc., may be photographed on sensitized paper and delivered in a few minutes time and at a reasonable cost, presents increased opportunities to the use of photo-reductions of drawings.

Bills of Material

Bills of material may range in importance from a table on the drawing used merely to amplify the information thereon given, to a combined

List of Material Required for 1 Carrier.

NO.	DESCRIPTION	MATERIAL	MARK
1	*$2\frac{15}{16}''$ x $9'$-$9''$ Shaft*	*C.R.*	*A*
1	*$2\frac{3}{16}''$ x $7'$-$3\frac{1}{2}''$ "*	"	*B*
1	*12 T. Sprocket $2\frac{15}{16}''$ bore #88 L.B.*	*Cast Iron*	*C*
4	*12 T. Sprockets $2\frac{15}{16}''$ " #88 "*	" "	*D*
4	*Journal Boxes*	*Mall.C.I.*	*E*
4	*" Box Springs*	*Steel*	*F*
4	*" " Brasses*	*Brass*	*G*

Fig. 215.—Simple bill of material form.

bill, production-order, and routing chart to which the drawing is only an explanatory attachment.

An example of a very usual type of bill of material written on the drawing itself is given in Fig. 215; while an example of the more complete type mentioned is shown by Fig. 216, being a form used by a modern general-manufacturing shop.

SEC. IV. CATALOGUE FILING AND INDEXING

General Remarks

A collection of the catalogues of the various manufacturing and supply companies may very well form a library hardly less valuable than

that of the usual engineering text books. This fact is recognized by all the large engineering firms, and the libraries of these companies provide for the filing and indexing of trade catalogues in the same manner as for books, periodicals, reports, etc. Smaller concerns, however, very frequently do not get as much good out of their collection of catalogues as they might under a suitable system of filing and indexing. Several systems are outlined below, each adapted to different requirements and points of view.

The filing and indexing of trade literature presents certain peculiar difficulties. There are no standards of size, arrangement, or methods of binding this material. A large and heavy volume and a two-leaf pamphlet may refer to exactly the same class of material and would logically be placed side by side on the shelves. One concern may issue separate booklets for each line of material manufactured, and another may catalogue thousands of widely varying articles under one cover. Also, one firm may issue one well-bound book at long intervals, and another may send along pamphlets every few weeks to be bound in a loose-leaf binder provided with the first few leaflets. In each instance, most probably, the exigencies of the business render each method the best for the conditions. Any system of filing and indexing must take due note of these circumstances, in addition to providing for the present and future requirements of consultants.

A Catalogue Filing System for a Small Purchasing Agent's Office

The name used above ("small purchasing agent's office") merely refers to one of a class having similar requirements. The purchasing agent usually has an intimate knowledge of the names of manufacturing and supply concerns, and the class of goods they handle. He requires a system that will locate at once the Blank Mfg. Co's. catalogue listing steel wheel-barrows for example: he does not care, particularly, to find out who supplies steel wheel-barrows, for he has other and better means of obtaining this information, nor is he concerned about the design of them as the draftsman might be. His system must be simple, it must keep the large catalogues and the pamphlets in separate files so that the latter will not get crushed and lost behind the former, and it must provide for the removal and rearrangement of any manufacturers' catalogue.

The following system has been in use for several years in a purchasing agent's office and has been found to answer the above requirements.

The catalogues are arranged on the shelves according to their size or binding; thus, all the large, heavily bound ones are placed together, the medium-sized ones are together, the small "pocket-size" ones are grouped on shelves of less height, and finally, pamphlets and leaflets

are placed in stout envelopes or ledger files and are filed vertically on the shelves. A letter mark is given to each of the above classifications; "A," "B," "C," "D," etc.—eight or ten are usually enough—and this letter is used as a prefix to a number for each catalogue on that shelf. Thus, the catalogues will be numbered A1, A2, B1, B2, etc., the numbering starting at "1" for each letter; the catalogues being filed, of course, according to their number. The mark should be written on a small gummed label and pasted on the upper left-hand corner of the cover.

For indexing, a card index is used, cards 3 in. × 5 in.; a sample card is shown in Fig. 217.

The cards are filed alphabetically, with a set of tabs of a suitable number of divisions to aid in quick location of a card. The user looks up in the card index the name of the manufacturer and is shown at once the number of the catalogue.

As there is no necessity for filing all the catalogues of one concern side by side, or of getting all catalogues on one class of article together, the system is capable of unlimited extension. Care must be taken,

Blake, Geo F, Mfg. Co	
Cambridge, Mass.	
Pumps, General	C13
Pumps, Sugar House	C31
Pumps, Vacuum	B3
Air Compressors	G18

FIG. 217.—Sample card, 3 in. × 5 in. for catalogue index.

of course, to fix up the card index whenever a catalogue is permanently removed or replaced by a new edition differently arranged. A cross index may be compiled if desired, based on the article manufactured and referring to the manufacturer, but its utility is doubtful in a small office.

A Catalogue Filing System for a Small Engineering Office

The draftsman or engineer who wishes to consult a catalogue library knows little, as a rule, concerning the names of the manufacturers. What he wants is to get together, with a minimum of effort, as many catalogues as possible illustrating and describing, say, high-speed four-valve engines. It is necessary, therefore, that all catalogues on one subject be grouped together on the shelves, so that all may be withdrawn at one motion. At the same time a system of indexing must be used that will enable the ready location of the catalogues of any given manufacturer. Furthermore, inasmuch as many engine builders for example, will list a great variety of engines in one catalogue (and will often include boilers, tube-cleaners, and what not), it is necessary that there be an index refer-

ring to any general catalogue that may describe, say, high-speed four-valve engines.

The system described below has been in use in a small engineering office for several years and fulfils all the requirements indicated above. In its operation the usual rule has been observed that any person may withdraw a catalogue, but only one man is allowed to file them, and to him also is entrusted the care of the card index, which must be kept continually up to date as new and revised catalogues arrive in the office.

In the first place a **topical index** with a decimal system of division was compiled, as a basis for filing. The index in its final development is reproduced below.

Topical Index for Catalogue Filing

Steam Boilers and Engines

1.0 Boiler and Engine Catalogues, General
1.10 Boilers and Superheaters only, General
  1.11 Fire Tube Boilers only
  1.12 Water Tube Boilers only
  1.13 Superheaters only
  1.18 Boiler Fittings only
1.20 Engines only—General
  1.21 Throttling Med. Speed only
  1.22 Automatic H.S
  1.23 Corliss Engines only
  1.28 Engine Fittings only
1.3 Steam Turbines only
1.4 Grates, Furnaces and Stokers
1.5 Smoke Stacks and Flues
1.6 Economizers
1.9 Boilers and Engines N. O. L. (not otherwise listed)

Pumps, Air Compressors, Condensers, etc.

2.0 Pumps, Air Compressors, Etc., General
2.1 Large Dir. Act. Pumps only
2.2 Power (Triplex, etc.) pumps only
2.3 Vacuum Pumps only
2.4 Centrifugal and Turbine pumps only
2.5 Air Compressors only
2.6 Condensing and Cooling Towers only
2.7 Artesian Pumps only
2.8 Pumps, etc., Fittings only
2.9 Pumps, etc., N. O. L

Steam and Water Fittings

3.0 Pipe and Fittings, General
3.1 Valves only
3.2 Separators and Traps only
3.3 Feed-water Heaters only
3.4 Instruments (Thermometers, Pyrometers, Gauges, Meters, etc.) only
3.5 Packing, Gaskets, Pipe Covering, etc., only

3 9 N. O. L

Water Turbines, Etc.

4.0 General Catalogues
4.1 Water Turbines only
4.2 Impulse Wheels only
4.3 Water Wheels only
4.8 Fittings only
4.9 N. O. L.

Gas Engines, Producers, Etc.

5.0 Gas Engine and Producer Cat's, General
5.1 Gas and Gasoline Engines only
5.2 Oil Engines only

5.5 Gas Producers and Gas Power Plants only
5 8 Fittings only
5.9 N. O. L.

Electrical

7.0 Electrical, General
7.1 Electrical Apparatus only
7.2 Electrical Supplies only

Conveying, Hoisting, Elevating and Power Transmission Machinery

8 0 General Catalogues
8.1 Pulleys, Shafting, Hangers, Gearing, etc., only
8 2 Conveyors and (Material) Elevators only
8 3 Freight and Passenger Elevators only
8.4 Derricks, Hoisting-engines, Wire-rope, etc., only
8.5 Cranes and Hoists only
8.6 Chain only
8.8 Belting
8.9 Material and Machinery N. O. L.

Mining Machinery, Rock Crushers, Etc.

10 0 General Catalogues
10 1 Mining Machinery only
10 2 Rock Crushers only
10 9 N. O. L.

Sugar Machinery (Specialty)

11.0 General Catalogues
11 1 Evaporators only
11 2 Vacuum Pans only
11 3 Filter Presses and Mech. Filters only
11 4 Centrifugals only
11 7 Distilling Machinery only
11 9 N. O. L.

Railway Supplies, Agricultural and Road Machinery

12 0 General Catalogues
12 1 Cars, Locomotives and Railway Supplies only
12.2 Wagons and Trucks only
12.3 Agricultural and Road Machinery only
12.4 Scales only
12 9 N. O. L.

Foundry Supplies

13 0 General Catalogues
13.1 Cupolas only
13.2 Blowers only
13.9 N. O. L.

Tools

15 0 General Catalogues
15.1 Machine Tools only
15 2 Wood Tools only
15.7 Hand tools only
15 9 N. O. L.

Construction Material for Buildings and Machinery

16 0 General Catalogues
16 1 Structural Steel, Plates, etc , only
16 2 Concrete Systems, Reinforcement, Machinery, Cement, etc.
16 3 Bricks and Brick machinery
16.4 Roofing and Flooring
16 5 Paints and Waterproofing
16 6 Hardware
16 8 Copper, Brass and Bronze
16 9 N. O. L.

Office Supplies, Books, and Instruments

20 0 General Catalogues
20 1 Drawing Office Supplies, Instruments, etc., only
20 2 Office furniture, etc.
20.5 Book Catalogues
20 9 N. O. L.

Miscellaneous

22 0 General (Dept. Store Mail Order Cat's, etc.)
22.1 Refrigerating and Ice-making Machinery
22 2 Tanks, etc.
22.9 N. O. L.

Such a classification as the Dewey System was not thought entirely satisfactory for the use of a small office. Due consideration was given to the usual methods of compiling trade catalogues; and to the peculiar needs of an office where general mechanical engineering and the design and construction of an industrial specialty were the principal operations. The headings may be subdivided indefinitely according to the decimal system (see p. 416); the first heading only is here shown subdivided.

As the catalogues came in they were **recorded** in the card index (see below) and were assigned to their proper location in the decimal classification, the figure being printed on a gummed label stuck on the upper left-hand corner of the cover. The catalogues were filed on shelves, and, as it became necessary to provide an **expandable system of divisions,** metal book supports of a special pattern were procured (see Fig. 218), the standard article not being high enough to show the decimal label above the tops of the catalogues.

Pamphlets, etc., that might become crushed and lost were filed in stout envelopes with the decimal number pasted on the outside.

By this method of filing, a draftsman or engineer who wished to get information on feed-water heaters, for example, found from the index that all catalogues relating to them were filed in 3.3, with a possibility that other information was contained under 3.0, which fact could be ascertained by consulting the card index.

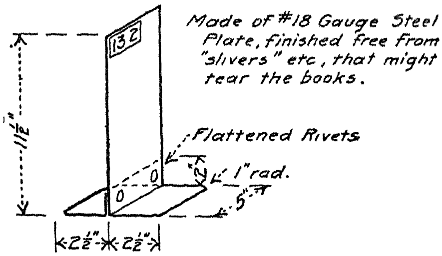


FIG. 218.—Metal book-support for catalogue file.

Two card indexes were maintained, one based on the name of the manufacturer and the other on the article catalogued. A card illustrating the first classification is given in Fig. 219.

These cards were filed alphabetically, the first name of the firm determining the location, cross-indexing being resorted to if necessary.

The "topical" or article card was prepared as shown in Fig. 220.

Chicago Pneumatic Tool Co.	
Air Compressors	2 5
Air Hammers, Hoists, etc.	15.7

FIG. 219.—"Manufacturer's" card for catalogue index.

These cards were filed according to the topical index given above.

Consultation of these card indexes and the catalogues on file gives quick information as to whether the catalogue of any manufacturer is on hand, where it may be found, and what manufacturers handle a

15 7	Hand Tools Only
	Chicago Pneumatic Tool Co.
	Wells-Bros ' Co
	Duff Mfg. Co.
	Ingersoll-Rand Co.
	Strelinger, C. H. Co.
	(etc , etc)

FIG. 220.—"Subject" card for catalogue index.

given article. Some knowledge of the system, and of the output of the larger dealers, is, of course, necessary to the best use of the files; this is inevitable unless a vast amount of cross-indexing is resorted to, the needs of each office must determine the amount of clerical work thought advisable.

As a case in point; the Chicago Pneumatic Tool Co. illustrate Air Hoists in their general catalogue, which, as shown on the card is filed in 15.7 (Hand Tools). Hoists, however, are classified under 8.5; and to take care of this, the 8.5 card should contain the name of the Chicago Pneumatic Tool Co. with the notation after it "(see 15.7)." In some offices the memory and general knowledge of some individual can be depended upon to locate such matters; larger offices, again, may require a still further amount of cross-indexing to make the collection of the greatest general value.

SEC. V. DRAWING OFFICE MISCELLANY

Methods of Obtaining Variable Prints from an Original Tracing

It frequently happens that a tracing, with slight modifications, can be used on a new job or on a number of jobs. It is usually not admissable to alter the original tracing because records will thereby be destroyed; and the time and expense of making a new tracing are also to be avoided. The following descriptions show the usual methods of obtaining the desired ends, ranging from the crudest to the most systematic.

(1) **By Altering Prints.**—As many prints as desired are taken from the original tracing, and figures, etc., altered to suit; either by obliterating the original lines by blue pencil (on the blueprint) and re-writing in ink or colored pencil, or by the use of soda solution or Chinese white.

It is necessary that a "record print" be kept to be filed under the new contract or estimate number.

Some method, also, is necessary to differentiate original and changed drawing numbers. Thus, supposing that the tracing bears the serial number "8104," it will be necessary to modify or alter this in some manner on the changed print, or confusion may arise in the future as to the drawing actually used on the job. A sure and simple method (although a clumsy one) is to designate the changed print as "No. 8104, Special Edition of June 21, 1913" for example.

(2) **By "Blackspotting."**—This method consists in placing blackened rectangles or circles on the tracing at all locations where figures, etc., may vary. These places print white on the blueprint, and the figures, etc., may be put in in ink on the print. A good example of the utility of this method occurs in the case of beam-detail sheets for office or loft building steel, where a large number of floors are alike. The girders framing between columns are often of the same section on all floors but differ in length, growing slightly longer from floor to floor on the way up as the column-section decreases. The length dimensions and the "Floor numbers" may be "blackspotted" on the tracing, and inserted on the blueprints. "General Dimension Sheets"

of standard machines may be treated in a similar manner; and many other applications of this useful method will present themselves when cost and time must be reduced to a minimum.

A "record print" should, of course, be kept, to be filed with the job records; and, with regard to the numbering of the print, the method of the last section may be used, or the more complicated method referred to in the next section, or (as in structural-steel work) a separate and distinct number may be given to each sheet.

(3) **By Lettered Dimensions and Key.**—This method is particularly applicable to "standard" drawings that are expected to be used on a number of different jobs. The dimensions that may be varied are lettered "A," "B," "C," etc., and a "key" or table on the tracing supplies the dimension used for each job. Such a "key" may take the form shown in Fig. 221.

Job No.	A	B	C	D	E	F		Remarks

FIG. 221.—Key for lettered dimensions on drawing.

A "record print" is usually not necessary, as the tracing forms a complete record. With regard to the number to be given the print, also, the original tracing number is usually sufficient, as there need be no mistake as to what dimensions were used on any job number. However, in some of the larger plants, a modified decimal system is used for numbering each variation, and for a complete description of such a system the reader is referred to p. 464.

(4) **By the Vandyke Process.**—This process consists in taking a "vandyke negative" from the original tracing; this "negative" resembling in every way an ordinary blueprint, except that the color is a dark brown instead of blue, and that it is usually printed "reversed." Any parts which are to be altered are then "painted out" on the negative with black or other opaque ink, and a "vandyke positive" is then made from the "negative." This "positive" will show dark brown lines on a white ground and parts that have been painted out on the "negative" will appear blank (white) on the "positive." The positive is then altered or completed to suit, just as a tracing would be, and prints taken from it in the regular way. It is necessary, in using the above method, that both "negative" and "positive" be made on thin paper, otherwise the resulting prints will not be "sharp."

There are several variations of the above useful process which may be developed to meet particular needs.

One very usual method is to obtain a "negative" and file it in place of the original tracing, taking prints from it (dark line on white ground) as required; the tracing itself is then altered to meet the new design. This method is simpler than the one first described, but might not work in so well with certain systems of filing and recording.

The cost for each vandyke print ("positive" or "negative") is about four times that of an ordinary blueprint.

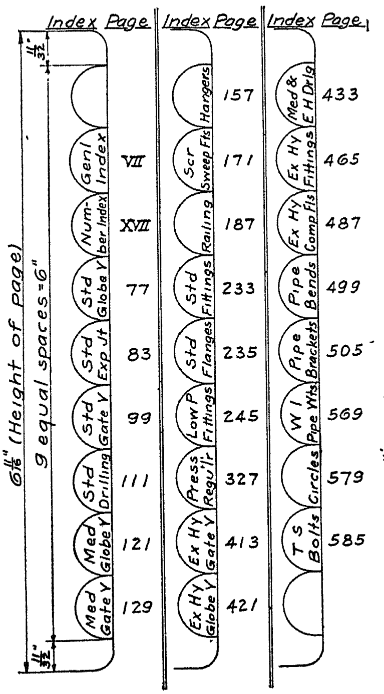


FIG. 222.—Thumb-index for "Crane" Pocket Cat. No. 40, Ed. of 1913.

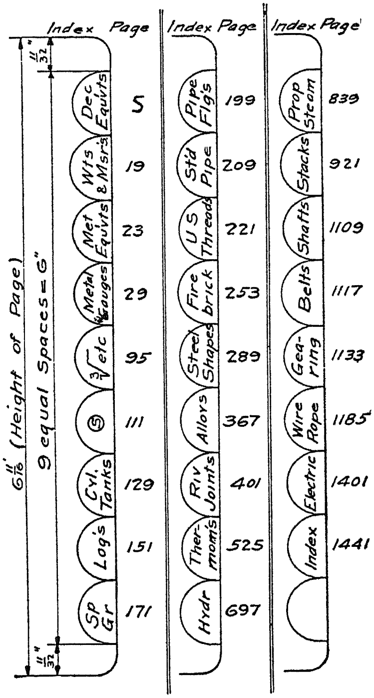


FIG. 223.—Thumb-index for "Kent," 8th Ed.

(5) **By New Tracings made by the Lithographic Process.**—It is now possible, by a so-called lithographic process, to obtain reproductions of tracings on tracing cloth. In cases where changes are desired on the copy, the original parts may be blocked out or removed on the stone, and the copy then finished as desired with ink in the usual way. It is necessary to submit a blueprint with the tracing, showing clearly (by colored pencil) what parts are to be blocked out. The cost of these reproductions is rather high (about 15 cents per square foot with an additional charge of 5 cents per square foot when portions are to be omitted), but, on complicated work, is only a fraction of the cost required to retrace the old drawing. The method is also useful for inter-plant work, as other offices

of a large company may each be supplied with a tracing of a much-used drawing at small expense.

Thumb-indexes for Standard Pocket-books

All pocket-books or tables requiring to be frequently consulted in an engineering office should be thumb-indexed. The later editions of some books are now issued with this device, but there are many books of tables, etc., in use around an office which may be advantageously indexed in this way. It is only necessary to mark off the location of the index with a

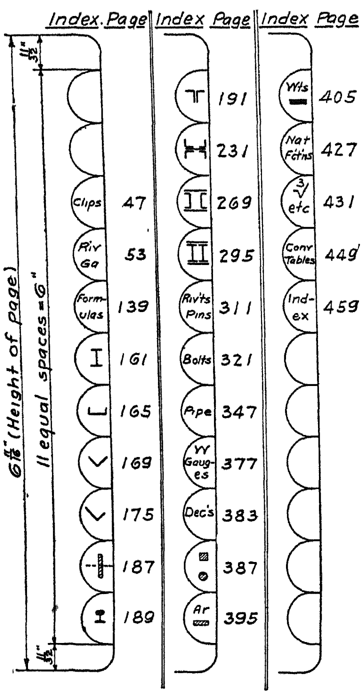


Fig. 224.—Thumb-index for "Cambria," Ed. of 1907.

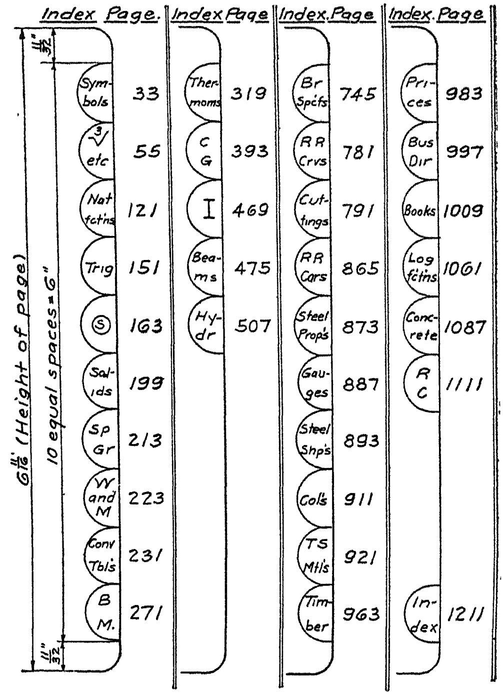


Fig. 225.—Thumb-index for "Trautwine" 19th edition, 1909.

half-circle on the facing side, and to then cut a sloping groove in the opposing pages with a gouge or a sharp pen-knife. All similar books in an office should be indexed in the same way, so that the whole staff may work with any book that happens to be at hand. The saving of time due to the installation of this simple device is very great. Indexes for a few of the more common hand books are given; they have been tried-out and found satisfactory.

Marking Schedules for Piping, Etc.

In listing and marking an extensive order of piping or similar equipment, mechanical engineers can advantageously borrow ideas from the

structural steel office. One of the most useful of the systems used by steel detailers is the "marking schedule," which, in its different forms,

MARKING SCHEDULE
HONOLULU IRON WORKS CO.
NEW YORK CITY

MARKS FOR Syrup Pipe for V.P. Supply Tanks
CARDS No 2486 LETTER MARK SP

	0	1	2	3	4	5	6	7	8	9
0		1	1	11	10	12	12	2	1	3
1	3	6	1	1	1	3	3-SP 3-SPA	3-SP 3-SPA	3	3
2	3	2	2							
3										
4										
5										
6										

MARKS FOR Discharge Water Pipe from Seal Tanks
CARDS No 2450 LETTER MARK CWT

	0	1	2	3	4	5	6	7	8	9
0		4	4	4	2	4	2	1	1	24
1	1	1	2	1	1	2	1	1	1	1
2	1	1	1	1	1	1	1	1	1	2
3	1					1	1	1	1	
4										
5	2	2	1	1	3					
6										

MARKS FOR Disch. Lines for Centrif. Mach. Oper. Pumps
CARDS No 2604 and 2607 LETTER MARK CP

	0	1	2	3	4	5	6	7	8	9
0		1	2	2	4	1	1	1	2	3
1	4	1	1	1	1	1	1	1	1	1
2	1	1								
3										
4	2	2	2	4	4	1	1	1		
5										
6										

JOB Cambria Sug. Co. CONT. No 176

FIG. 226.—Pipe marking schedule.

is used to indicate the number of columns, beams, etc., of the same mark, and to show on what sheet the detail will be found.

The schedule shown in Fig. 226 is one that has been modified to the

needs of pipe draughtsmen. As fittings or lengths of pipe are given marks on the drawing, the total number of similar pieces required is marked on the schedule; thus, on Drawing No. 2486 of Syrup Piping, if there are three similar tees given the mark "SP15," the figure "3" is written in the square indicated by the coördinates "1" and "5": these figures being written in pencil so that they may be readily altered. If any pieces are later withdrawn, the marks are cancelled; it is not necessary that the sequence of marks be kept intact.

When all pieces have been marked on the drawing, the schedule is a material aid to the making-out of the pipe-list of the specification (see p. 122), as the number of units of each mark is given in the table directly.

The principal advantage of the system is the protection it affords against the duplication of marks and the omission of material in the list, frequent sources of error when several men are working on a large job. It will not, of course, entirely eliminate mistakes of this character; but it will (as has been abundantly proved in the author's practice) reduce them to a minimum.

The schedules are useful, also, in quickly indicating on what drawing piping of a known mark or service may be found.

Revising Drawings

It should be an invariable rule in every drawing office, that any revision made on a tracing is to be fully recorded on the drawing and indicated in such a way that the change is at once apparent to the user. The observance of such a rule, however, is, at the present time, an exceptional occurrence; and the only notification given the recipient of a revised print is usually in the form of a letter, and sometimes not even that. Consulting engineers and manufacturers are equally lax in this respect, and many costly mistakes may be traced to the lack of proper notification on a print that it is "revised" and that "old copies should be destroyed."

The following scheme is offered as one which has been in use for some time and has proven satisfactory.

Before revising a tracing obtain a print from it and mark it "Record B/P, See Revision," and file away with other records: if any question should come up as to the original arrangement, this print will clear up the point.

After the alteration, stamp the tracing with such a blank as is shown in Fig. 227 and fill in, enumerating the changes briefly. Also alter the drawing number by the addition of a letter "A" for the first revision, "B" for the second, etc.; this may be placed in the "prime" position (*e.g.*, 2741^{B}) or separated by a dash (*e.g.*, 2741–B).

All prints made from a revised tracing should be stamped as per Fig. 228, and the alterations indicated by arrows, etc., in colored pencil; or, the stamp may be put on the tracing in the first place.

Another method of indicating revisions on tracings and prints which has some advantages over the first, consists in using the same stamp as in Fig. 227, and also a stamp as shown in Fig. 229.

This arrow mark is stamped on the tracing pointing to every change, and the letter mark of the revision ("A," "B," etc.) is written inside the feather. Thus every change, and the issue to which it belongs, is

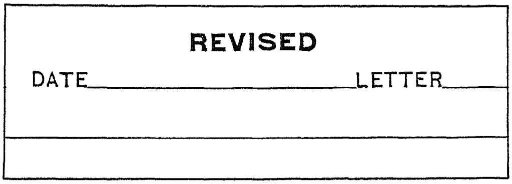


FIG. 227.—Stamp for use on revised tracings.

recorded on the tracing, and no such stamp as shown in Fig. 228 is necessary, and no marking has to be done on the blueprints. However, as these changes often do not show up very strikingly on the print, some such stamp as "Revised, Destroy Old Copies" had best be used on the revised prints also. Another advantage of the second method is that no additional letter is given to the drawing number: this suffixed letter is inadmissable under certain systems of drawing numbering, more particularly in structural steel detailing, where such sheet marks as "E1, E2, etc.," are in general use.

Portions of this print
affected by Revision———
are indicated in Red.

FIG. 228.—Stamp for use on revised blueprints.

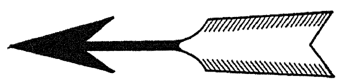


FIG. 229.—Stamp for indicating revised portions of a tracing.

MISCELLANEOUS STAMPS FOR DRAWING OFFICE USE

Below are given examples of rubber stamp inpressions of general use in drawing offices.

Other stamps are shown elsewhere in this volume as follows:

Figs. 100, (a), (b) and (c)—*Approval* stamps, used when approving or correcting contractor's detail drawings.

Figs. 227 and 229, *Revised* stamps for tracings.

Fig. 228, *Revised* stamp for blueprints.

Fig. 230. A stamp for blueprints, specifications, etc., calling attention to the issuance of revised copies.

REVISED,
DESTROY OLD COPIES

Fig. 230.

SUPERSEDED

Fig. 231.

THIS DRAWING IS
NOT CHECKED,
DO NOT USE
FOR CONSTRUCTION

Fig. 232.

ORIGINAL
DUPLICATE
TRIPLICATE

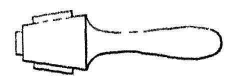


Fig. 233.

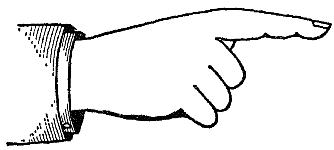


Fig. 234.

Our quotation is based on the information given on this print. If the business is placed with us, this print must accompany order.
HONOLULU IRON WORKS CO.

Fig. 235.

THIS IS THE PROPERTY OF THE
HONOLULU IRON WORKS CO., HONOLULU, T. H.
New York Office: No. 11 Broadway,
AND IS LOANED TO

. . . .

subject to recall at any time and is to be used only in connection with the particular work for which it is prepared and upon the express condition that it is not to be copied, made public, or used in any way without the written authority of the

HONOLULU IRON WORKS COMPANY

Fig. 236

ERECTOR'S
COPY

Fig. 237.

RECEIVED
DEC. 26, 1912
HONOLULU IRON WORKS CO.
NEW YORK

Fig. 238.

BLANK
IRON WORKS CO.
ENGINEERS
Dec. 27, 1912
29 Broadway NEW YORK

FIG. 239.

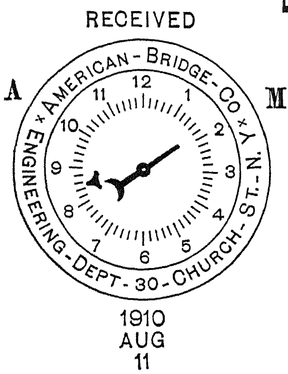


FIG. 240.

CONTRACT No.________
CARD NO.________ DRAWN BY________
TRACED BY________ CHECKED BY________
SCALE________ DATE________
HONOLULU IRON WORKS CO.
29 BROADWAY NEW YORK.

FIG. 241.

CONT. NO.________ DRWG. NO.________
JOB________
TITLE________
____
____
HONOLULU IRON WORKS CO.
29 BROADWAY NEW YORK, U.S.A.
MADE BY________ TR. BY________ CHK'D BY________
SCALE________ DATE________

FIG. 242.

THE BABCOCK & WILCOX CO.
GENERAL OFFICES NEW YORK, N. Y. WORKS BARBERTON OHIO BAYONNE, N. J.
SETTING OF TUBULAR BOILER WITH BAGASSE & COAL FURNACES FOR
CENTRAL AGUIRRE
DRAWN BY *W. H.M.* INSPECTED BY *R.H.B.*
TRACED BY *H. M.* SCALE *½ inch* = 1 FT.
DATE JUNE 19, 1909
DRAWING No. D2319

FIG. 243.

Fig. 235. A stamp to be used on prints on which an estimate is made and which have to be returned to the owners: a precaution against additional material or requirements being called for on final prints.

Figs. 241, 242 and 243 are examples of *Title* stamps. The last has its title made up in a small printing-press, the permanent part being the subject of a single block.

Fig. 236 is an example of stamps used quite commonly to protect designs; it is of doubtful utility, however.

Figs. 238 and 240 are examples of stamps used to denote the date (and hour) when blueprints, letters, etc., entered the office.

Fig. 239 shows a stamp of general usefulness, as, for example, in dating issued blueprints.

The other figures show stamps of general utility.

CHAPTER XIII

MISCELLANY

Abbreviations Used in Engineering Work

A collection of abbreviations commonly (and uncommonly) used in engineering work, and such as are not generally tabulated in the well-known engineering pocket-books is given below.

Transmission Machinery

C.R. = cold-rolled (shafting)
D.B. = double-belt (pulley)
S.B. = single-belt (pulley)
K.S. and S.S. = key-seat and set-screw (in pulley)
20 in. × 4 in. × 1 9/16 in. (pulley) = 20 in. diameter × 4 in. (nominal) face × 1 9/16 in. bore
P.D. = pitch-diameter (of gear-wheel)
P. = pitch (of gear teeth)
F. = face (of gear or pulley)
B.G. = bevel gear
R.P.M. = revolutions per minute
F.P.M. = feet per minute
T. and L. = tight and loose (pulleys)
S.F. = straight face (pulleys)
C.F. = crown face (pulleys)
R.O. = ring-oiling (bearing)
R.O.C. = ring-oiling collar (bearing)
B. and S. = ball and socket (bearing)

Piping

O.S. and Y. = outside screw and yoke (valve)
I.S. = inside screw (valve)
I.B. = iron-bodied (valve)
B.F. = brass-fitted (valve)
VL. = valve
F. and D. = faced and drilled
F.O. = faced only
Flgd. = flanged
F.E. = flanged end
Scr. = screwed
L.R. = long-radius (fitting)
L.S. = long-sweep (fitting)
O.D. = outside diameter (pipe)
I.D. = inside diameter (pipe)
E.H. = extra heavy (pipe or fitting)
D.E.H. = double extra heavy (pipe or fitting)
F.W. = full weight (pipe)

I.P. size = iron pipe size (brass pipe or fitting)
D.B. = double-branch (long sweep elbow)
S.S. = single sweep (long-radius tee)
S B. = straight back (long sweep tee)
S.O. = side outlet (tee, cross, etc.)
H.H. and N. = hexagon head and nut (bolt)
Sq H., H.N. = square head, hexagon nut (bolt)
C.P. = cold pressed (nut)
T. and C. = threaded and coupled (wrought pipe)
B. and S. = bell and spigot (cast-iron pipe)
C.I. = cast iron (pipe or fitting)
W.I. = wrought iron (pipe)
G I. = galvanized iron (pipe or fitting)
R.P. = riveted pipe
Mall. I. = malleable iron (fitting)
Blk. = black (pipe or malleable fitting)
C. to F. = centre to face (of fitting)

Pumping Machinery and Hydraulics

S. = single (cylinder)
D. = duplex (double cylinder)
D.A. = double acting
S.A. = single acting
Dir. A. = direct acting
O.P. = outside packed (plunger)
C.O.P. = centre outside packed (plunger)
E.O.P. = end outside packed (plunger)
B.F. = brass fitted
comp. = composition (water end, etc.)
12 in. × 6 in × 10 in. = (12 in.) dia of steam cyl. × (6 in.) diam. of water cyl. × (10 in.) stroke = d × D × s.
8 in. and 12 in. × 6 in. × 10 in. = d and d × D × s = dia high pressure cyl. and diameter low pressure cyl. × diameter of water cyl. × stroke
R.P.M. = revolutions per minute
G.P.M. = g/m = gallons per minute
H.M.D. = hydraulic mean depth (cross-sect. area of stream ÷ wetted perimeter)

Steam Engineering

H.P. = horse-power
I.H.P. = indicated horse-power
B.H.P. = brake horse-power
10 in. × 12 in. (engine) = (10 in.) diameter cyl. × (12 in.) stroke
10 in. and 18 in. × 15 in. = d and d × s = diameter of high-pressure cyl and diameter of low pressure cyl. × stroke
H.S. = high speed (engine)
S.V. = slide-valve (engine)
c.-o. = cut-off (steam in cyl.)
M.T. = multi-tubular (boiler)
W.T. = water-tube (boiler)
S.S. = self-supporting (stack)
M.E.P. = mean effective pressure (steam on piston)
I.P. = initial pressure (steam on piston)
B.P. = back pressure (steam on piston)
R.P.M. = revolutions per minute

Locomotives

A method of designating the number and class of wheels of a locomotive devised by **Mr. F. M. Whyte** that has been quite generally adopted, gives as the first figure the number of leading truck wheels, as the second the number of drivers, as the third the number of trailing wheels (on the loco). If there is a separate tender, the number of wheels under the tender will be given as a fourth figure (or fifth for Mallet Articulated engines).

Also, certain abbreviating letters are used, as follows: if a Saddle Tank, the letter "S;" Side Tanks "T;" and for Rear Tanks "R" follow the numbers giving the wheel arrangement.

Another system, which indicates also the diameter of the cylinders, is described in the following extract from "Locomotive Data" issued by the **Baldwin Locomotive Works.**

"Systems of classifying locomotives have been proposed from time to time, the principles of these being shown on the following pages. The diagram shows graphically in the first column the arrangement of wheels, and in the second column the generally applied name as used in the United States. The third column shows the Baldwin Locomotive Works' designation, and the fourth that proposed by Mr. F. M. Whyte. The names are largely those applied by the first local users of the respective types of locomotives.

"The Baldwin Locomotive Works' notation employs figures and letters to indicate the number of wheels of different kinds and the size of cylinders. A locomotive having one pair of driving wheels is classed as "B," that with two pairs, "C," with three pairs, "D," with four pairs "E," and with five pairs, "F." The letter "A" is used for a special class of high-speed locomotive with a single pair of driving wheels, and for a smaller type used for rack rail service. In articulated locomotives a letter, as above, is used to designate the number of driving wheels in each group. A figure is used as an initial to indicate the total number of wheels under the locomotive, and the letter, as stated above, indicates the number of driving wheels. The size of the cylinder is, of course, not shown in the third column but is represented by a number, which is found by subtracting 3 from the diameter of the cylinder in inches and multiplying the remainder by 2; thus, a 19-in. cylinder would be represented by the number 32, so that a Mogul locomotive with 19-in. cylinders would be termed an 8–32D. Conversely, the size of cylinder may be obtained by dividing the class designation for cylinder by 2 and adding 3.

"When there are trucks at both ends of the locomotive the fraction 1/4 is placed after the cylinder number and when there is a truck at the rear end and none at the front, the fraction is 1/3. Thus, a Mikado type locomotive with 19-in. cylinders would be a 12–32 1/4E, and one of the Forney type would be 8–32 1/3C.

"The same rule is carried out in the classification of compound locomotives. In this case, however, a number is given to indicate the diameter of each cylinder, that indicating the high pressure being written over the low pressure. Thus, 10–22/42D100 indicates a compound locomotive with ten wheels in all, having high-pressure cylinders 14 in. in diameter and low-pressure cylinders 24 in. in

Representation	Type	Baldwin Symbol	Whyte Symbol
◢ □ ◯◯	4-Wheeled Switcher	4 -C	0-4-0
◢ □ ◯◯◯	6-Wheeled Switcher	6 -D	0-6-0
◢ □ ◯◯◯◯	8-Wheeled Switcher	8 -E	0-8-0
◢ □ ◯◯◯◯◯	10-Wheeled Switcher	10 -F	0-10-0
◢ ○ □ ◯◯		6 -C	2-4-0
◢ ○ □ ◯◯ ○		8¼-C	2-4-2
◢ ○ □ ◯◯ ○○		10¼-C	2-4-4
◢ ○ □ ◯◯◯	Mogul	8 -D	2-6-0
◢ ○ □ ◯◯◯ ○	Prairie	10¼-D	2-6-2
◢ ○ □ ◯◯◯ ○○		12¼-D	2-6-4
◢ ○ □ ◯◯◯◯	Consolidation	10 -E	2-8-0
◢ ○ □ ◯◯◯◯ ○	Mikado	12¼-E	2-8-2

Representation	Type	Baldwin Symbol	Whyte Symbol
◢ ○ □ ◯◯◯◯◯	Decapod	12 -F	2-10-0
◢ ○ □ ◯◯◯◯◯ ○	Santa Fe	14¼-F	2-10-2
◢ ○ □ ○ ◯ ○		8¼-A	4-2-2
◢ ○ □ ○ ◯◯	American	8 -C	4-4-0
◢ ○ □ ○ ◯◯ ○	Atlantic	10¼-C	4-4-2
◢ ○ □ ○ ◯◯◯	10-Wheeled	10 -D	4-6-0
◢ ○ □ ○ ◯◯◯ ○	Pacific	12¼-D	4-6-2
◢ ○ □ ○ ◯◯◯◯	12-Wheeled	12 -E	4-8-0
◢ ○ □ ○ ◯◯◯◯ ○	Sierra	14¼-E	4-8-2
◢ ○ □ ○ ◯◯◯◯◯	Mastodon	14 -F	4-10-0
◢ □ ◯◯ ○		6⅓-C	0-4-2
◢ □ ◯◯ ○○	Forney	8⅓-C	0-4-4

Representation	Type	Baldwin Symbol	Whyte Symbol
◢ □ ◯◯◯ ○		8⅓-D	0-6-2
◢ □ ◯◯ □ ◯◯	Mallet Articulated	8 -CC	0-4-4-0
◢ ○ □ ◯◯ □ ◯◯	" "	10 -CC	2-4-4-0
◢ ○ □ ◯◯ □ ◯◯ ○	" "	12¼-CC	2-4-4-2
◢ ○ □ ◯◯ □ ◯◯◯	" "	12 -CD	2-4-6-0
◢ ○ □ ○ ◯◯ □ ◯◯◯ ○	" "	16¼-CD	4-4-6-2
◢ □ ◯◯◯ □ ◯◯◯	" "	12 -DD	0-6-6-0
◢ ○ □ ◯◯◯ □ ◯◯◯ ○	" "	16¼-DD	2-6-6-2
◢ ○ □ ◯◯◯ □ ◯◯◯◯	" "	16 -DE	2-6-8-0
◢ □ ◯◯◯◯ □ ◯◯◯◯	" "	16 -EE	0-8-8-0
◢ ○ □ ◯◯◯◯ □ ◯◯◯◯	" "	18 -EE	2-8-8-0
◢ ○ □ ◯◯◯◯ □ ◯◯◯◯ ○	" "	20¼-EE	2-8-8-2
◢ ○ □ ◯◯◯◯◯ □ ◯◯◯◯◯ ○	" "	24¼-FF	2-10-10-2

FIG. 244.—Locomotive classification (Baldwin Locomotive Works).

diameter, with three pairs of driving wheels and the one-hundredth locomotive of its class.

"This final figure indicating the class number of the locomotive is used in connection with all engines regardless of the types to which they belong."

For designating the "Service," the following abbreviations are often used: "P" = passenger; "F" = freight; "M" = mixed; "S" = switching.

Lumber

S. 1S. = surfaced one side
S. 2S. = surfaced two sides
S. 1S. 1E. = surfaced one side and one edge
S. 4S. = surfaced four sides, etc.
D. and M. = dressed and matched
B.M. = board measure (feet). (1 ft. B.M = 1/12 cu. ft)
M.B.M. = thousand feet board measure
M. = thousand (shingles, etc)

Erection Tools

M.R. = Manila rope (blocks)
M.B. = metalline bushed (blocks)
D.C.D.D. = double-cylinder, double-drum (hoisting engine)

Civil Engineering (Miscellaneous)

m.p.h. = miles per hour (wind)
1:2:5 (concrete) = 1 part cement to 2 parts sand to 5 parts stone, all by volume
1:3 (cement mortar) = 1 part cement to 3 parts sand, by volume
B.M. = bench mark (surveying)
P.C. = point of curve (R.R. surveying)
P.T. = point of tangency (R. R. surveying)
P.I. = point of instrument (R. R. surveying)
H.I. = height of instrument
O.H. = open hearth (steel)
A.O.H = acid open hearth (steel)
B.O.H. = basic open hearth (steel)
Nick = nickel (steel)

Mechanical Engineering (Miscellaneous)

E.O.T. = Electric Overhead Traveling (Crane)
O.T. = Overhead Traveling (Crane)
H.H. and N. = Hexagon Head and Nut (Bolts)
Sq.H., H.N. = Square Head, Hexagon Nut (Bolts)
C.P. = cold pressed (nut)
R.P.M. = revolutions per minute
S.L.R. = single lap riveted (joint)
D.L.R. = double ditto

Electrical Engineering (Miscellaneous)

A.C. = alternating current
D.C. = direct current
Dir. Conn. = direct connected (engine and generator)
Gen. = generator

cyc. = cycles (of alt. current)
ϕ = phase
ph. = phase
v. = volts
amp. = amperes
K.W. = kilowatts
k.w.h. = kilo-watt-hours
K.V.A. = kilo-volt amperes (alt. cur.)
o. = ohms.
P.F. = power-factor (alt. cur.)
S.P. = single pole (switch)
D.P. = double pole (switch)
S.T. = single throw (switch)
D.T. = double throw (switch)

Shipping

B/L = bill of lading
S/L = shipping list
f.o.b. = free on board (cars or vessel)
f.o.r. = free on rails (English expression)
f.a.s. = free alongside steamer For definitions see p. 212
C/I/F/ = c.i f. = cost, insurance and freight (paid)
C.L. = carload (of freight)
L.C.L. = less than carload (of freight)
N.O.S. = not otherwise specified
K.D. = knocked down (tanks, etc.)
S.U. = set up (tanks, etc.)
R.U. = riveted up (tanks, etc.)
P.P. = prepaid
I.C.C. = Interstate Commerce Commission
O R. = owner's risk
E.E. = errors excepted
E. and O.E. = errors and omissions excepted
F.P.A. = free of particular average (insurance)
A.O.S. = (except) as otherwise specified
Inv. = invoice
C.D. = cubic dimensions
C/O = certificate of origin
S/P = ship's permit
P/R = pier receipt
S/M = shipper's manifest
Ship's/M = ship's manifest

Consulting Engineers' Fees

The following description of fees usually charged by consulting engineers is extracted (by permission) from "Engineering as a Vocation" by Ernest McCullough.[1] It supplies tangible data on a subject about which the engineer who has always worked on a salary is usually not well informed. In another part of the book the author gives the date of writing as 1907.

[1] David Williams Co., New York, 1911.

"The general charge for consulting engineers is $100 per day, with expenses added when the employment takes them away from their home city. A great many good men can be obtained for $50 per day. Men who have worked up a fairly good practice on medium and small work and who are seldom engaged by the more wealthy employers, charge $25 per day. The average engineer in private practice starts out with a charge of about $15 per day for strictly consultation work, and $10 per day for ordinary work. In places of less than 25,000 inhabitants the usual rate is about $8 per day, while surveyors seldom charge more than $5 per day for their work. The day of an engineer away from his office is not 8 hours, but is generally counted from an hour before the sun rises until as far into the night as is necessary to get his notes in shape. A number of years ago the writer was located in a small western town and his charges were as follows: Important work of a strictly consultation nature $25 per day for less than 1 week, plus expenses; and when work lasted more than a week the charge was $25 for the first 3 days, $20 for the next 3 days, and $15 for the remainder of the time. Few jobs of this kind lasted more than 3 days, the sliding scale being an inducement to get longer employment, an artifice that often succeeded. For general work such as surveying, drafting and taking charge of construction, $10 per day and expenses for less than 20 days' work; for more than 20 days' work, $10 per day for the first 10 days and $9 per day for the second 10 days, after which the charge was $8 per day for the following 30 days, dropping to $6 per day and remaining at that level until the completion of the work. There were two reasons for this sliding scale, the first and most important being that it acted to make jobs last longer; the second being that the high-class work is generally the first part of every job. After the plans are made the work is of such a routine nature that the average employer is tempted to dismiss a highly paid man and employ a cheaper one to look after the execution of the contract. This is where the average employer makes a mistake, and few can be made to see it that way, but they are willing to employ as a superintendent, the man who planned the work rather than put on a stranger, provided the difference in pay is not great. The work in that section was of such a nature that no engineer could employ assistants to do his work, all employers insisting upon the personal attention of the engineer,———."

"When men in large cities ask less than $25 per day and expenses for their services, it is understood they have severe competition; how severe it is impossible to tell."

Schedule of Fees for Engineering Services

Below is given the "Recommended Schedule of Fees of the Connecticut Society of Civil Engineers" as adopted Feb. 10, 1914; it is offered as one of the best and most up-to-date of many similar schedules.

The following schedule of charges for professional services are intended as a guide to engineers and their clients. It is believed that, in ordinary practice, a fair and proper compensation for engineering services will lie somewhere be-

tween the minimum and maximum charges given in the schedules. It is recognized, however, that the magnitude of the work and the experience or reputation of the engineer frequently justify a decrease or increase from the schedules below.

Charges may be based on any of the following methods, or a combination of the same, A, as a percentage of the cost of the work; B, a fixed sum; or C, a per diem rate.

(A) PERCENTAGE OF THE COST OF THE WORK

(1) For preliminary conferences, preliminary studies, estimates and reports, from 1 to 1½ percent of the cost of the work.

(2) For the services outlined in (1), for the design, and for the preparation of contract drawings, specifications, and contracts, a total charge of from 2½ to 5 percent of the cost of the work.

(3) For the services outlined in (2), for advice in letting contracts, and for general supervision during construction, a total charge of from 4 to 8 percent of the cost of the work.

(4) For full professional services, including complete supervision and inspection of construction, a total charge of from 6 to 12 percent of the cost of the work.

When no contracts are let, but the work is done under the business management of the engineer, the additional compensation depends to such an extent upon conditions that it should be a matter of special agreement between the engineer and his client.

In the preliminary stages the cost of the work is based on the estimated cost; later it is based on the cost of all labor and materials necessary to complete the work, plus the contractor's profit and expenses. The cost of both labor and materials should be based on market prices current when the work was ordered, the labor to be fully paid and the materials to be considered as new.

Payments should be made from time to time as services are rendered, the amounts to be based upon the proportion of services completed.

(B) A FIXED SUM

(1) A fixed sum for services may be agreed upon in lieu of a percentage or a per diem charge, and an additional charge made for expenses.

(2) A fixed total sum of all services of principal or assistants and for all attending expenses.

A fixed sum may be charged for a portion or all of the items of preliminary surveys, studies, examinations, reports, plans, specifications and supervision, etc., either with or without attending expenses.

(C) PER DIEM RATE

(1) For expert services, reports, consultations, opinions, expert testimony, depending on the experience of the engineer and the character, magnitude and importance of the work or subject involved, a charge of from $25 to $100 per day.

(2) For time of consulting engineer on designs and for more ordinary services, examinations, reports, etc., a charge of from \$15 to \$50 per day; 7 hours of actual time to be considered 1 day, except that, while absent from city or attending court, each day of 24 hours or part thereof shall be considered 1 day irrespective of actual hours of time devoted to the case.

Additional charges should be made for all actual expenses and assistants. The cost of assistants shall be determined by adding to the payment for wages 50 percent for overhead charges.

GENERAL PROVISIONS

Traveling expenses and expenses involved in making borings, soundings or tests, or in the collection of similar data necessary for the proper designing or planning of the structure or project, should be paid for by the client in addition to the commission herein provided for, it being understood, however, that all ordinary measurements and surveys shall be considered a part of the regular work of the engineer for which no extra compensation shall be expected.

When alterations or additions are made to contracts, drawings, or specifications, or when services are rendered in connection with legal proceedings, franchises or right-of-way, or failure of contractors, a charge based upon the time and trouble involved shall be made in addition to the commissions herein provided for.

It is recognized that in any work undertaken by an engineer there may be problems requiring the services of a specialist. The cost of such special assistance shall be paid by the client.

Drawings and specifications, by any method of payment for services, are to be considered the property of the engineer, but the client is entitled to receive one record of the same upon payment of the actual cost of making the copies if no duplicate set is at hand.

Good designing may be vitiated by poor construction, especially in any work which requires careful supervision and inspection during its progress, such, for example, as reinforced-concrete work.

For this reason it is for the best interests of the client that the engineer be given full direction of the work during the construction period, or, if this is impracticable, that the client employ experienced inspectors approved by the engineer and working under his general supervision.

EDWARD W. BUSH, JOHN C. TRACY, HERBERT C. KEITH,
Committee.

An Agreement or Contract Form for Engineering Services on Export Work

The following is a contract-form which is suitable in those cases where a firm of engineers makes designs and prepares plans and specifications for material for a factory or other similar work in a foreign country; payment being based on a percentage of the cost of material. By suitable changes in the wording it could be made to cover a percentage payment on cost of completed structure.

THIS AGREEMENT, made the ——————— - -- - --- - — — -in the year one thousand nine hundred and ——— —by and between - - — -
—————————————————————party of the first part (hereinafter designated the Engineer —), and ——————————————————— —— — --- - - — —-party of the second part (hereinafter designated the Owner —),

WITNESSETH that the Engineer—, in consideration of the agreements herein made by the Owner—, agree with the said Owner— as follows:

General Description of Contract

Art. I.—That the Engineer—will act as Consulting Engineer—to the Owner—on the construction of the factory known as - - — - - ---- --- situated at ——————————————————— - -- - —, said factory to be used for ——————————————————————— — ——— —and to have a capacity of about ——————————————— -- - - ——.

Preliminary Plans

Art. II.—That the Engineers will prepare preliminary general plans and specifications, sufficiently complete to illustrate the character and scope of the work, and will submit them to the owner—for———approval, and will alter these plans and specifications as may be necessary to secure a final approved design, which will be certified by the owner by ———signature of approval thereon.

Plans for Bidders

Art. III.—Immediately following approval of the preliminary plans the Engineer—will proceed to prepare the working plans and specifications necessary for obtaining suitable bids on the machinery, building steel, or all other material that must be purchased in the U. S. Plans and specifications for not to exceed five bidders on each installation will be supplied by the engineers, the bidders to be as selected by the Owner, or at ———selection on the advice of the Engineer—.

Erection Plans and Lists

Art. IV.—The Engineer—agree to prepare and to transmit to the Owner —, sufficiently in advance of the time of proposed construction, all plans and specifications requisite for making excavations, building foundations and erecting buildings and machinery; copies to be supplied to the Owner —in triplicate, of which one set of plans will be made on cloth. The Engineer—also agree to prepare and to transmit to the Owner —all lists, drawings and specifications as, and at such times as may be necessary for the purchase of local material, that is to say cement, sand, stone, brick and timber required in the construction of the factory; not to exceed five sets of such lists, drawings and specifications to be supplied.

Advice on Bids

Art. V.—The Engineer—also agree to advise the Owner—to the best of ——knowledge and ability, covering the completeness, fairness and relative desirabilities of the bids received; and concerning the reliability and capability of the bidders.

Expert Advice

Art. VI.—The Engineer—agree, in the prosecution of the design and handling of the work, to use and to unreservedly place at the disposal of the Owner—, the results of——best judgment based on ——experience as ————————— during the last ————————— years on - - - ————————— ————————— work.

Changes

Art. VII.—In the event that, after the approval by the Owner—of the preliminary plans and specifications, any changes are required by the Owner —involving alterations in plans, calculations, or specifications already made or partly made, or involving the making of new calculations, plans or specifications, the additional cost to the Engineer—of making such changes or renewals is to be paid for by the Owner—at the actual salary charges of the Engineer — assistants, plus an overhead charge on same of 50 percent to cover the usual overhead charges of the Engineer—business.

Abandonment

Art. VIII.—In the event that, after the preparation by the Engineer—of the corresponding plans and specifications, any part of the work shall be abandoned by the Owner—, the commission that shall be due the Engineer—shall be as follows:———percent for the preliminary plans and specifications and an additional———percent for the working plans and specifications if prepared, both on the estimated cost of the material as hereinafter specified.

Inspection

Art. IX.—Inspection of material or machinery in the U. S. is to be made where, and at such times, as may be agreed upon from time-to-time between the Owner—and the Engineer—. For brief inspection visits, the Engineer —agrees to furnish and to pay the salary of a competent inspector, but his necessary traveling and living expenses, when away from—————————are to be paid by the Owner—. In the event that the Owner —elects to have material inspected by a firm or by an individual constantly on the ground, the total charges of such firm or individual are to be paid by the Owner—.

Special Services

Art. X.—In the event that conditions may arise foreign to the class of work covered by this agreement and calling for the services of a special practitioner, the cost of such special services is to be paid by the Owner —.

Invoices and Shipping Papers

Art. XI.—All matters pertaining to the shipment of the material will be attended to by the Owner—, except that the Engineer—agrees to verify all invoices and to check all shipping lists to verify, as far as possible, the correctness and completeness of the shipment. The Owner—agrees to furnish the Engineer — with one copy of each of these documents, which are to be retained by the Engineer—for———records.

Ownership of Drawings, Etc.

Art. XII.—All drawings, lists and specifications are to be considered the property of the Engineer —, but the Owner—is to be furnished with one complete set of blueprints of the same for his records.

Preliminary Engineering Work

Art. XIII.—In the event that it is agreed to despatch an engineer to the site of the factory for the purpose of making preliminary drawings, soil tests, or other necessary investigations, the whole expense of such service is to be borne by the Owner—.

Services of Erector

Art. XIV.—At such time as may be agreed, the Engineer—agree to furnish the services of a skilled Superintendent to oversee the work of erection of the factory. The charge for his services is to be at the rate of $——— per month, counting from the time he leaves——— ——— until his return, which charge together with all his necessary traveling expenses, is to be paid by the Owner—.

Payments

Art. XV.—In consideration of the above agreements, the Owner—agree—to pay to the Engineer—a commission of———percent on the cost of all building material, machinery, or other equipment entering into the construction or installation of the factory, with the exception—hereinafter enumerated. The basis of such commission is to be the export invoice value of the goods in case the same are shipped from the U. S. or other country; the value of the material delivered on the ground in the case of such material as is purchased or otherwise acquired locally; or the estimated value of material as above in the case of such payments as cannot be based on actual values.

It is further agreed, however, that no commission is to be paid on any labor, export-freight, insurance or other incidental expenses that may occur in connection with the erection of the factory.

It is further agreed that said commissions are to be due and payable to the Engineer as follows:———percent on completion of the preliminary plans and specifications, and the remaining ———percent from time to time in proportion to the amount of work being done by the Engineer—in———office.

Art. XVI.—The said parties do hereby agree to the full performance of the covenants herein contained.

____________________ Engineer —.

per ____________________

Approved and accepted____________________, 19—.

____________________, Owner—

per ____________________

Standard Form of Contract Between Architect and Owner

The following is a short standard form for this contract; it is offered as an example of a suitable form for the use of engineers. The reference to the "published schedule of fees of the American Institute of Architects" would have to be omitted and written in detail, using some such schedule as that of the Connecticut Society of Civil Engineers (p. 515); and, in fact, the form may be regarded simply as a framework on which the pertinent clauses of this schedule may be hung.

CONTRACT BETWEEN ARCHITECT AND OWNER

From.., Architect

to.., Owner.

For a compensation of..

the architect proposes to furnish preliminary sketches, contract working drawings and specifications, detail drawings and general superintendence of building operations, and, also, to audit all accounts, for a..

to be erected for..

on..

Terms of payment to be as follows:

One-fifth when the preliminary sketches are completed; three-tenths when the drawings and specifications are ready for letting contracts; thereafter at the rate of —— percent, upon each certificate due to the contractor. . . . . .

If work upon the building is postponed or abandoned, the compensation for the work done by the architect is to bear such relation to the compensation for the entire work as determined by the published schedule of fees of the American Institute of Architects.

In all transactions between the owner and contractor, the architect is to act as the owner's agent, and his duties and liabilities in this connection are to be those of agent only.

A representative of the architect will make visits to the building for the purpose of general superintendence, of such frequency and duration as, in the architect's judgment, will suffice, or may be necessary to fully instruct contractors, pass upon the merits of material and workmanship, and maintain an effective working organization of the several contractors engaged upon the structure.

The architect will demand of the contractors proper correction and remedy of all defects discovered in their work, and will assist the owner in enforcing the terms of the contracts; but the architect's superintendence shall not include liability or responsibility for any breach of contract by the contractors.

The amount of the architect's compensation is to be reckoned upon the total cost of the building, including all stationary fixtures.

Drawings and specifications are instruments of service, and as such are to remain the property of the architect.

——————————, Architect.

Approved and accepted—————— ——————————, 19 .

——————————, Owner.

The rules of the A.I. of A. were amended in December, 1913, and the following "Conditions of Contract Between Architect and Owner"[1] are prescribed for inclusion in any contract between members of the institute and an owner. It will be noted that the duties of each are specified in greater detail, especially with reference to compensation for expert engineering services.

CONDITIONS OF CONTRACT BETWEEN ARCHITECT AND OWNER

Article I—Duties of the Architect

1. **Design.**—The architect is to design the entire building and its immediate surroundings and is to design or direct the design of its constructive, engineering and decorative work and its fixed equipment and, if further retained, its movable furniture and the treatment of the remainder of its grounds.

2. **Drawings and Specifications.**—The architect is to make such revision of his competitive scheme as may be necessary to complete the preliminary studies; and he is to provide drawings and specifications necessary for the conduct of the work. All such instruments of service are and remain the property of the architect.

3. **Administration.**—The architect is to prepare or advise as to all forms connected with the making of proposals and contracts, to issue all certificates of payment, to keep proper accounts and generally to discharge the necessary administrative duties connected with the work.

[1] From "Eng. Record," May 23, 1914.

4. **Supervision.**—The architect is to supervise the execution of all the work committed to his control.

Article II—Duties of the Owner

1. **Payments.**—The owner is to pay the architect for his services a sum equal to 6 percent[1] upon the cost of the work. (The times and amounts of payments should be here stated)[2]

2. **Reimbursements.**—The owner is to reimburse the architect, from time to time, the amount of expenses necessarily incurred by him or his deputies while traveling in the discharge of duties connected with the work.

3. **Service of Engineers.**—The owner is to reimburse the architect the cost of the services of such engineers for heating, mechanical and electrical work as are specifically provided for in each program. The selection of such engineers and their compensation shall be subject to the approval of the owner.

4. **Information, Clerk-of-the-Works, Etc.**—The owner is to give all information as to his requirements; to pay for all necessary surveys, borings and tests, and for the continuous services of a clerk-of-the-works, whose competence is approved by the architect.

Outline of Agreement or Contract for Services of a Structural Steel Erector

By altering the character of service, etc., the outline herein given may be used for any mechanical or professional services of similar character.

THIS AGREEMENT made this ———— day of ———— 19— between ————of the city of ————party of the first part, and————of the city of ———— party of the second part,

WITNESSETH, that the parties have agreed and do hereby agree as follows:

Character and Period of Services

ART. I.—That the said ——— party of the first part does hereby assert that he is a competent structural steel erector of ——— years' experience and that he is competent to erect and to supervise the erection of steel bridges, buildings and similar structures.

Party of first part agrees to leave the city of ——— on or before - - — -- and to proceed by shortest and quickest route to ——— and there to erect - - - and such other structures as the party of the second part, or their authorized agent, may direct, or to go to any other place and erect such other structures as party of second part may direct, for the period of 1 year from date of his leaving ——— or for a longer period as provided in Art. II.

Party of 1st p. agrees to carry forward the work, and to train other men to the work, so that it will be carried out in a workmanlike and satisfactory manner and with proper diligence.

Party of 1st p. agrees to work every day except Sundays and holidays legal in State of ———.

[1] Some competitions may be for work in which all or certain parts command a higher percentage, and in such cases this should be named in the contract.

[2] Good practice has established the payments on account as follows: Upon completion of the preliminary studies one-fifth of the total estimated fee less the previous payment; upon completion of contract drawings and specifications two-fifths additional of such fee; for other drawings, for supervision and for administration, the remainder of the fee, from time to time, in proportion to the progress of the work.

A day's work is understood to be of ——— working hours.

P. of 1st. p. agrees to give his whole and undivided attention to the work, and not to engage in any other occupation or employment while working for p of 2nd p., except by written permission of p. of 2nd p.

Extension of Service

ART. II —In case that work is not completed in ——— months or in case p. of 2nd p desires it, p. of 1st p. agrees to continue the period of his service for ——— months, all the articles of this contract applying to the extended period.

Transportation to Site

ART. III.—P. of 2nd p. to transport ——— p of 1st p. from ——— to ——— in a first-class manner, to pay all hotel bills en route necessitated by delay due to making transportation connections. Transportation to be by quickest route unless otherwise directed by p. of 2nd p. P of 2nd p. also agrees to pay all other expenses of transportation properly incurred by p. of 1st. p. in service of p. of 2nd p. when traveling as directed by p. of 2nd p.

Rate of Compensation

ART. IV.—For and in consideration of services described in Art. I ——— p. of 2nd part agrees to pay ——— p. of 1st p. the sum of ——— dollars per day in U. S. gold coin for every day of contracted period except for Sundays. Pay to start on day that ——— p. of 1st p. leaves ———, and to continue until ——— p. of 1st p. arrives at ——— on his return. P. of 2nd p. also agrees to provide ——— p. of 1st p. with board and medical attendance while at work. In case ——— p. of 1st p. is sick and incapacitated from work, his pay shall be reduced to ——— dollars per day.

Payment to be made (weekly) (monthly).

In Case of Sickness or Disability

ART. V.—In case of sickness or disability, p. of 1st p. is to provide p. of 2nd p. with a doctor's certificate of the fact.

If, by reason of such sickness or disability, p. of 2nd p. may so desire, said p. of 2nd p. may discontinue the provisions of this contract relating to time of service, providing p. of 1st. p. with transportation back to city of ——— in manner provided in Art. III, and may enter into contract with another party and take such other steps as p. of 2nd p. may desire to forward the progress of the work in absence of the services of p. of 1st p.

In Case of Incompetence, Etc.

ART. VI.—In the event that p. of 1st p. may, by reason of incompetence, drunkenness or insubordination, render himself incapable of carrying on the work, p. of 2nd part may discharge said ——— p. of 1st p. from their service and all the clauses in this contract relating to transportation back to city of ——— and compensation until that time will be null and void.

Transportation from Site

ART. VII.—At the expiration of time of contract given in Art. I or at the expiration of the work if same is not completed by that time ——— p. of 2nd p. agrees to furnish ——— p. of 1st p. with cost of his transportation back to ——— in a first-class manner by the most direct route, in same manner as provided in Art. III.

In case ——— p. of 1st p. desires to return to ——— by any other route than the most direct, or to otherwise direct himself, p. of 2nd p. agrees to pay ——— p. of 1st p. only such sum of money as would be needed for his return by the most direct route as mentioned in first part of this article.

In Case of Death

ART. VIII.—In the event of the death of ——— p. of 1st p. while in employ of p. of 2nd p., said p. of 2nd p. agrees to bury the body of p. of 1st p. in a suitable manner near the scene of his death.

——— p. of 2nd p. further agrees to pay to the estate of p. of 1st p. the cost of transportation to ——— of p. of 1st p. that would have been incurred, together with the working daily compensation mentioned in Art. IV from time he was incapacitated until such time as would have been required for him to return to ———.

——— p. of 2nd p. also agrees to furnish estate of p. of 1st p., if desired, with statement of decease or death certificate of said p. of 1st p.

In witness of the foregoing, the parties above said have set their hands and seals to this and one other instrument of like tenor and date and year first above written.

——————————— (Seal)

Erector

——————————— (Seal)

Engineer for ———————

In presence of

——————— for ———————

——————— for ———————

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